

Waste Management Principles and Practices

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About the Book

As a global village, we have the responsibility of waste management. With the help of techniques like Polluter Pays Principle, Assimilative Capacity principle and Precautionary principles, the problem of waste management can be solved to an extent which further gets expanded in a gradual manner. Waste management can be tackled by using certain strategies that are designed to solve this issue in an intricate way which is beneficial for the greater good of the global community. The objective of this book is to enhance knowledge and understanding of the students on the subject of waste and provide new perspectives and fresh insights towards addressing the issue of waste management in our nation.

This book provides a comprehensive view of the waste management system in India, the systemic challenges and the innovative solutions. The book provides a view of the ecosystem, its components and functions, linkages between the UN sustainable goals and waste management, circular system and linear system of waste management and the innovative techniques of sustainable waste management. The book provides insights into the waste generation in India and across the world, reasons for the increase in waste quantity, impacts of excess waste generation, principles of waste management, waste characterization, sources of waste, types of waste, solid waste management tools and other types of waste, source reduction, waste reduction strategies, present scenario of solid waste management in urban local bodies and rural areas and waste disposal practices, the sustainability tools including life cycle analysis, environmental management system, corporate social responsibility and waste management, extended producer responsibility, take back scheme and sustainable materials usage.

The rapid industrialization, increased population and heightened consumerism prevalent in our society has led to a huge generation of waste and subsequent clearing by dumping in landfills or burning in incinerators. This linear system of waste management has severe impacts on our environment resulting in scarcity of resources which is clearly not sustainable. Given this context, the world over organizations, countries and the governments have experimented with an approach called the Circular system that adopts the principle of reduce, reuse and recycle of waste for better waste management. The circular system uses natural systems, low energy, low-technology, small scale and a decentralized approach at the community level to manage waste in a sustainable manner.

Project management has gained increasing attention from various fields recently especially waste management. Project managers are in general facing enormous pressure. As effective project managers, they should have three fundamental competencies, including the competency of understanding project information, the competency of identifying and integrating project resources, and the competency of transforming conceptions into project deliverables. To possess the three competencies, project managers should have effective ways of project management thinking. The effective ways of project management thinking are more useful to project management practitioners. In fact, it is common that various project tools (e.g. Critical Path Management, Work Breakdown Structure, etc.) are not applied in projects even though project managers have learned these tools.

The book provides an insight into project management concepts and implementation in waste management. Every project and as a consequence every project manager has to deal with different targets, different environments and, last but not least, with different people. Therefore, only the Know-how and the Do-how will transform a project manager into an excellent project manager.

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. Logistics in waste management is primarily used as a tool for an appropriate management of all kinds of waste that not only enables the minimization of pollutants generated, but also allows for redevelopment or disposal of waste. Managing huge amount of wastes generated on a day-to-day basis added by the rising costs and unsafe disposal are the problems of the day. With the involvement of communities and the private sector, advanced technologies and safe disposal methods, and inculcating lifestyle changes and creating awareness, cities around the world are showing remarkable results by adapting good practices in waste management.

One of the best ways to combat waste management is to make sure that the collected waste is used and reused in the form of fuel, domestic gas and electricity. This is one of the major ways in which waste can be managed so that it becomes easier to dispose it and also use it to the best of its capacity. Waste management requires a lot of cost production and also the disposal of these materials requires a lot of machinery which has to be done in a cost effective manner. Containers and segregators for each segment of waste are to be maintained so that the correct way of managing the solid waste is completed in an effective manner.

Rapid increases in the human population and in consumption per capita threaten to stretch the planet's capacity to sustain growth beyond its limits. The time has come to closely understand 'Product Life Cycles" move away from the 'take, make, dispose' paradigm of production and consumption, which has dominated global society since the Industrial Revolution, towards what has been termed a 'Circular Economy', which incorporates recycling into the production-consumption cycle.

The Resource Efficiency & Recovery concept offers multiple benefits, which have gained recognition in recent decades under various guises: including ecological economics, green growth and sustainable development. The United Nations Agenda 2030 and its 17 Sustainable Development Goals (SDGs) acknowledge the environmental limits to growth and human well-being. The environment features prominently in many targets of the SDGs – particularly SDG 2 on food security and sustainable agriculture, SDG 6 on water reuse and water for ecosystems, SDG 12 on waste recycling and reuse and SDG 15 on restoring degraded soils, to name a few.

The goal of the Resource Efficiency and Recovery, is for business administrators, leaders, and entrepreneurs to assess business viability not only in the short term but for the future generations who will demand their services. The idea is for businesses to internalize the wider environmental costs and benefits in their production decisions and to make consumers complicit in these decisions.

This book showcases real examples from around the world, demonstrating how plant nutrients, energy and water can be recovered from what is currently viewed as 'waste' – avoiding their unregulated disposal into the environment and associated costs (e.g. health costs, clean-up costs), while also capturing the financial value associated with reuse of the treated or recycled resource. The book covers a wide range of value propositions to maximize cost recovery and social or financial benefits. The case studies and the models discussed can inform broader programs aimed at scaling up good practices, they will contribute importantly to the achievement of many SDG targets, including SDG 11 on more resilient cities.

This book is suitable for students of all streams - Commerce, Humanities, Science, Management, Journalism, Mass Media, Healthcare services (B Pharm, Social Work), Education, and Engineering. The extent of environmental damage and the innovations in combating the issues require scientific understanding of the subject. The subject has vast possibilities and several interlinking themes. There is extensive scope to explore and experience different aspects of sanitation, pollution, environmental hygiene and waste management during classroom learning, practical experiments in field and laboratory, internship and dissertation. There is a sea of opportunity in this field of waste management and environmental hygiene, and an urgent need of skilled as well as dedicated workers to make our country clean and green.

Acknowledgement

This book represents the collective efforts of many remarkable individuals. We would like to thank the contributors to this volume for their collective wisdom, experience and insight. Envisioned by Shri VLVSS Subba Rao, Senior Economic Advisor, MHRD, the book took shape under his keen guidance.

We would like to thank our Subject authors: Dr Sonal Chaturvedi, Capacity Building Expert, Mumbai; Dr Sachin Kamble, Professor at A. C. Patil College of Engineering , Navi Mumbai; Dr Bajepally Venkata Subbarao, Advisor, Centre for Climate Change, Engineering Staff College of India Resource Education and focus on capacity building training programs in climate centered diversified sectors.

Our special thanks to Ms. Almitra Patel, Member Supreme Court Committee on Solid Waste Management, whose website, www. almitrapatel.com, has been a sea of information for drawing and developing the book.

We would like to thank Major Shiva Kiran, Consultant, MGNCRE; Vani G, MGNCRE and MGNCRE team members including Editor, Ms. V Anasuya and Designer, Mr. G Sivaram for extending their support in completing this book.

Block 1

Introduction to Waste Management

Swachhta Action Plan

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सत्यमेव जयते

Where there is Rural Wellbeing
there is Universal Prosperity

Contents

Introduction to Waste Management

With rapid urbanisation, the country is facing massive waste management challenge. Over 377 million urban people live in 7,935 towns and cities and generate 62 million tonnes of municipal solid waste per annum. Only 43 million tonnes (MT) of the waste is collected, 11.9 MT is treated, and 31 MT is dumped in landfill sites.

The impact of the waste dumping system that is legally practised today is humungous—to human health, environment and the socio-economic well-being of an estimated two million waste-picker families who live off the dumping grounds today in India.

Nearly 40% of the waste-pickers are children aged below18 years, what is definite is that these families live off in unhygienic environments, succumbing to malnutrition, extreme poverty, and adverse health infections.

With no physical protection such as gloves, uniforms, shoes or masks, most children scourge for metals with magnets attached to sticks, thus putting their health to extreme risk. Several studies have been published that link asthma, heart attack, and emphysema to burning garbage. Human faecal matter is also frequently found in municipal waste—this, along with unmanaged decomposed garbage, attracts other rodents, that further lead to a spread of diseases such as dengue and malaria.The key to efficient waste management is to ensure proper segregation of waste at source and to ensure that the waste goes through different streams of recycling and resource recovery.

Installation of waste-to-compost and bio-methanation plants would reduce the load of landfill sites. The biodegradable component of India's solid waste is currently estimated at a little over 50 per cent. Bio-methanation is a solution for processing biodegradable waste which is also remains underexploited. It is believed that if we segregate biodegradable waste from the rest, it could reduce the challenges by half.

There has been technological advancement for processing, treatment and disposal of solid waste. Energy-from-waste is a crucial element of SWM because it reduces the volume of waste from disposal also helps in converting the waste into renewable energy and organic manure. Ideally, it falls in the flow chart after segregation, collection, recycling and before getting to the land fill. But many wastes to energy plants in India are not operating to their full potential.

While on the one hand, India needs highly scientific and automated mechanisms of managing the huge volumes of waste, on the other, facilities need to be decentralised to enable efficient management of end-to-end operations and save on transportation costs. Only two cities, Pune and Bengaluru have implemented by-laws recommending decentralised processing of waste. The rest of the country has stayed on with centralised dumping of waste onto earmarked areas for landfill, leading to perverse incentives, waxing transportation costs and massive air and water pollution.

Chapter 1 Introduction to Environment

Introduction

Mother Earth is the only planet in the entire Universe which supports life and Living Beings i.e. plants, birds, animals and human beings. The technological breakthroughs in space research and subsequent exploration of planets in our solar system; highlights the unique nature of planet earth to provide the basic ingredients of water, air (O2/CO2) and soil/oceans, necessary for growth of life.

The warmth and energy from Sun help fuel a food cycle using the basic ingredients and the living beings in the food cycle. Living being becomes non-living being when it is finished by predation or natural death. The non-living being is left as a body entity. On predation they fulfill the food chain for other living beings as shown below. However, on natural death also the now non-living parts are consumed and broken up into multiple micro fragments to be utilized by organisms.

The illustrative food chain diagram shown below explains how the plant roots are effectively decomposed and broken down by the microbial creatures like Bacteria, fungi and protozoa both on land and in sea for providing nutritional food for the food chain. This bio-diversity and the balance of waste by utilizing it is a gift from mother nature to all living beings.The micro/mini and small organisms eat, grow, and move through the soil and ensure clean water, clean air, healthy plants, and moderated water flow. This is the unique nature of our environment to effectively utilize and have zero wastage of its resources i.e. the living and non-living beings.

Fig1.1: Inter-dependent food cycle on EARTH

Homo-sapiens have flourished on earth due to their intelligence, team work and adaptability. The development of language, communication and co-ordination led to formation of villages and agrarian society with a slow population growth which was localized in regions. This lasted until 16th Century.

The growth in technological capability, invention of machines and transport equipment's led to increasing exploration by man for more natural resource and setting up of mass production centres. This led to growth of urban cities and from the 1950's to 1980's, the world population was expanding very fast. The improvement in the health and living conditions was contributing to the growth of population to 7 times in the last 200 years.

At the start of the 21st century, all countries across the world realized the finite resources for supporting human beings on planet and the need for a planned usage of resources.

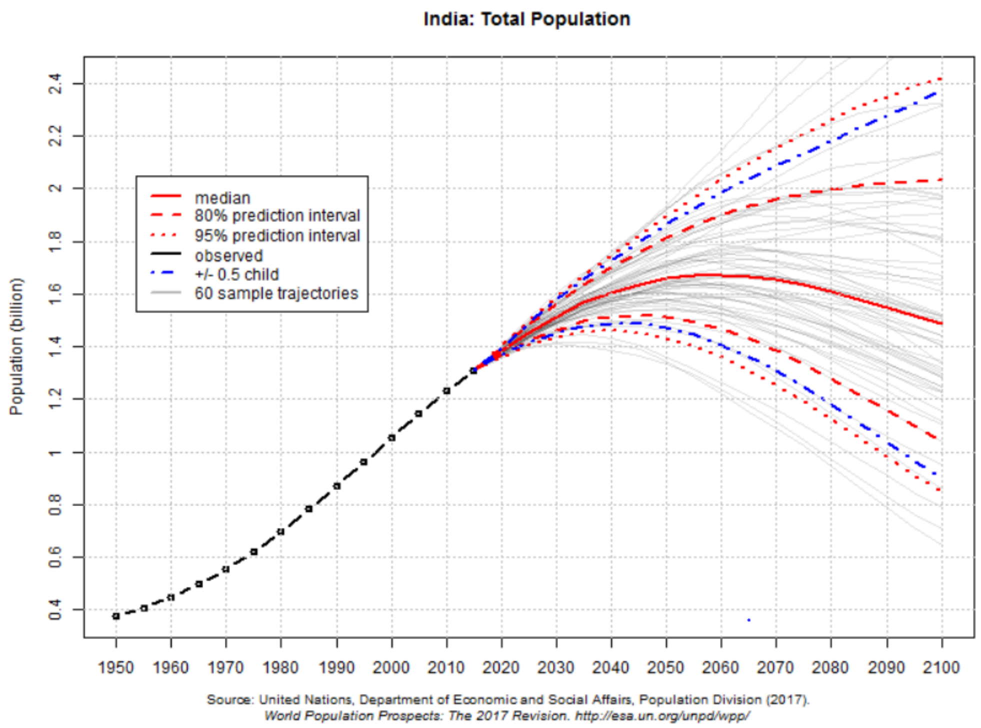


Fig 1.2 Illustrative growth of Population from 1950 to 2100https://population.un.org/wpp/Graphs/Probabilistic/POP/TOT/

Human beings were intelligent and had increased the agricultural production enough to sustain large populations. However, the same human being was overlooking the fact that the food was not being distributed uniformly to all. Further, the excess food was being carted out as a waste which had to be collectively cleared by the Government of the day.

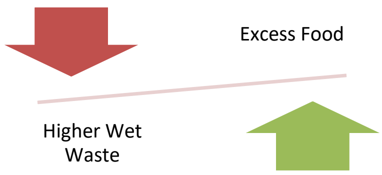


Fig 1.3 Proportional increase in food waste with higher allocation

The excess food which is thrown away or wasted constitutes the wet waste. The wet waste constitutes at least 70% of the daily waste which is being carted out from household. This waste must be processed for generating compost or bio-gas for consumption. The wet waste is a daily output from each household. The mixing of the wet waste with dry waste i.e. the papers, plastics and bottles (elements which can be recycled or reused) and hazardous waste like light bulbs, electronic PCB causes a mammoth effort to segregate them and send them for separate processing as shown below

Fig 1.4 Wet waste segregation

The awareness needs to be increased among fellow citizens to do the segregation right at the first place and save the effort required by other personnel. The management of the waste, the multiple types of handling of waste and the magnitude of waste requires a scale of operation which must be self-sustainable, generate energy and income for all sections of society. The waste management as a subject has been successfully implemented in Sweden which recycles 99% of its waste.

Objectives

- Describe the components, structure and functions of our ecosystem – Food Chain and Trophic Structure, Biogeochemical cycles
- Explain the levels of organization in nature
- Linkages between the UN Sustainable development goals and waste management
- Comparative analysis of Cyclic vs Linear waste movement
- Identify the Innovative methods to revert from Linear to Cyclic management

1.1 Our Ecosystem – Meaning, Components, Structure and Functions

An ecosystem consists of all the living things in an area together with the abiotic, non-living parts of that environment such as nitrogen in the soil or rain water. Example: Forests

Planet Earth where we live constitute multiple living and non-living entities in each area. The balance among them is determined by the environment and the interactions between them. Each one is dependent on the other and the interactions are complex requiring in-depth understanding and management. The components of the eco-system are as shown below in Fig5.

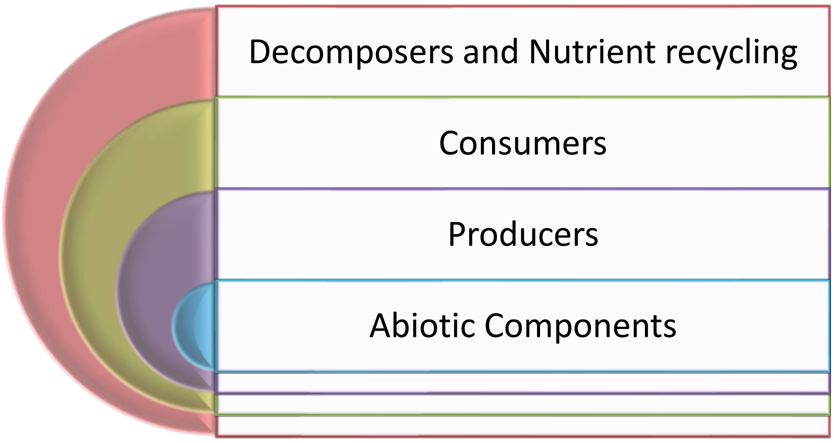


Fig 1.5 Different components of the Eco-system

Multiple areas also interact and influence each other to form a total inter-dependent system as shown below in Fig6.

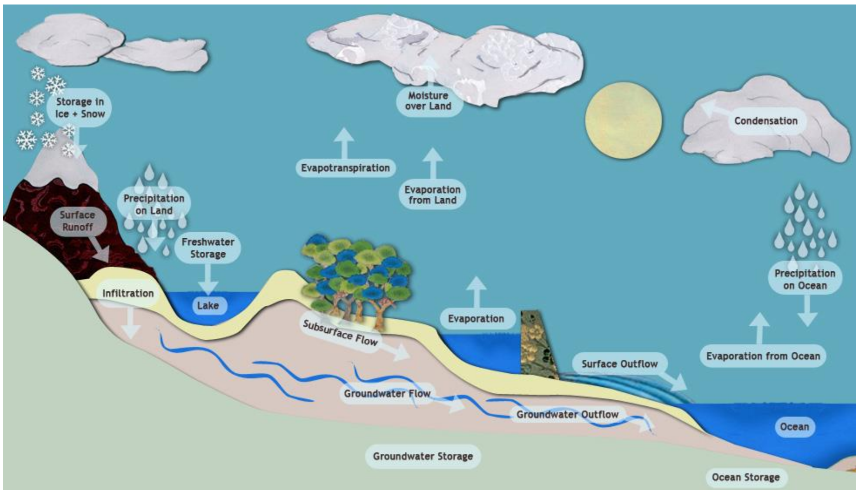


Fig 1.6 Water and Soil ecosystem showing the water cycle as a part of biogeochemical cycle

http://www.khoryug.com/resources/sciencesolutions/

To Do Activity

Film Analysis and discussion
what are the problems being discussed ?
What are the solutions being offered ?
What are the learnings from the film?
https://www.youtube.com/watch?v=cBxN9E5f7pc
https://www.youtube.com/watch?v=Otz-FZ7QuI8https://www.youtube.com/watch?v=jpf7lyxgy5I

Abiotic Components

The base of the eco-system in an area are the abiotic components. All the non-living elements of the eco-system are the abiotic components. The abiotic components are specific to an area and present in natural formation or modified by human expansions. The water bodies around the area like lakes, rivers, ponds are primary sources of all living beings. They are dependent on the monsoon rain fall or the perennial glaciers in Himalayas for top up and sustainability. Nutrients and minerals are spread over a topography by the flowing water and the ground water. The sunlight allows the micro-organisms and plants to carry out photosynthesis and energy generation. The soil provides the nutrients and minerals required by living organisms to thrive and grow in the locality.

The climatic factors of the abiotic components are the following:

- Rain/ Light / Wind/ Temperature

The Edaphic factors of the abiotic components are the following:

- Soil and PH/ Minerals/Topography

Charged waterbody due to monsoon fed rivulets near sea in Puri District leading to abundant flora and fauna

Ganges (water from glaciers accumulated due to snowfall) winding its way through the plains near Haridwar

Continued

Low water level from scanty monsoon rains supporting low level trees and migratory birds in Nal sarovar, Gujarat

Heavy Rainfall during monsoon leading to vegetation growth at height near Pune

Fig 1.7 Abiotic Components

Producers (Photosynthetic) at the Base

Producers are the critical link to abiotic components and the next level of food chain. The producers utilize the energy from sunlight to transform the carbon dioxide and oxygen in the atmosphere into sugars. They transfer inorganic carbon, nitrogen and critical minerals into the food chain. Primarily plants, algae and photosynthetic bacteria are all part of the producers at the base. The nutritional value of the producers is high and hence the bio-mass and the coverage in nature is very high.

High trees in Himalayas near Manali processing the sunlight

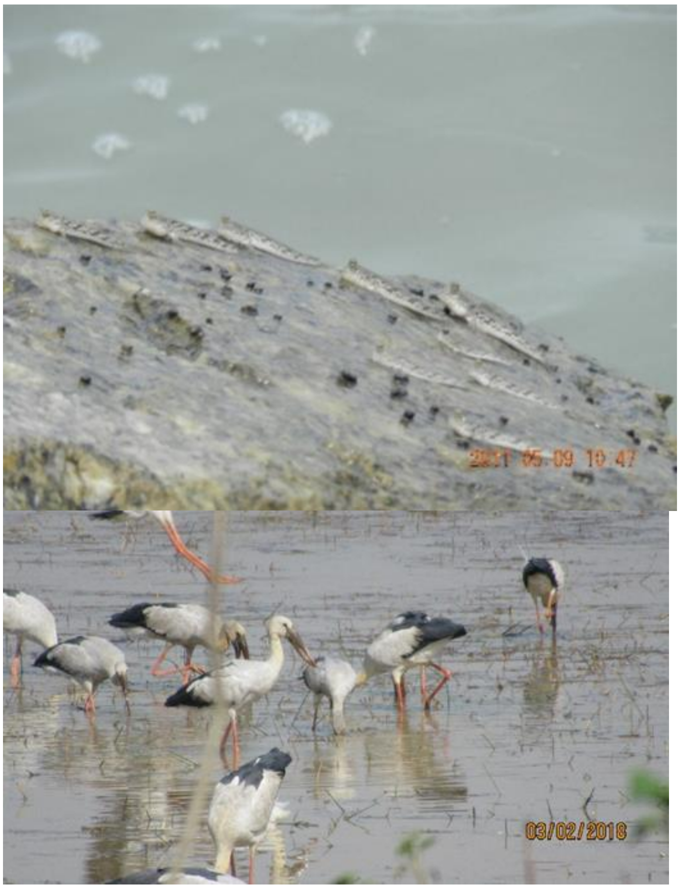
Algae on rocks utilizing sunlight and photosysnthesis to grow on rocks near Arabian sea at Murud Janzira fort

Fig 1.8 Producers at the base

Primary Consumers in the Chain

Consumers are living organisms in the ecosystem that get their energy from consuming other organisms and divided into Herbivores and carnivores.

The producers are consumed by herbivores and the herbivores are consumed by the carnivores. There are omnivores who are both herbivores and omnivores. Consumers are able to harvest 10-30% of the food intake, so the foot print of their biomass is lesser than the producers in the food chain.



Herbivore consumer – Tadpole feeding on Algae near bay of bengal. They become omnivores on growth into an adult

Carnivore Consumer – Storks feeding on tadpoles and fish near Puri

Fig 1.9 Consumers in the chain

To Do activity

Film analysis and discussion
https://www.youtube.com/watch?v=ZvhdTIbPS9s
https://www.youtube.com/watch?v=7V8oFI4GYMY
What are the problems being discussed in the film?
What are the solutions being offered?
What are your key learnings from the film?

Decomposers and Nutrient Recycling

Decomposers are the living members of the eco-system which breaks down the waste material and non-living bodies to release the nutrients, chemicals back into the soil or the water. The typical examples of the decomposers are algae, bacteria and earth worms. The Trophic cycle explaining the food chain is as shown below in Fig 1.10.

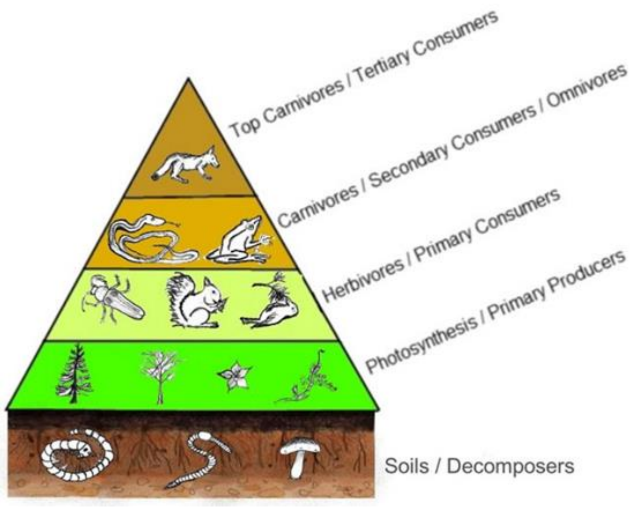


Fig 1.10 Trophic Cycle

1.2 Levels of Organization in Nature

The extension of the living organism is limited in the earth's environmental sphere to biosphere as shown below in Fig1: 11.

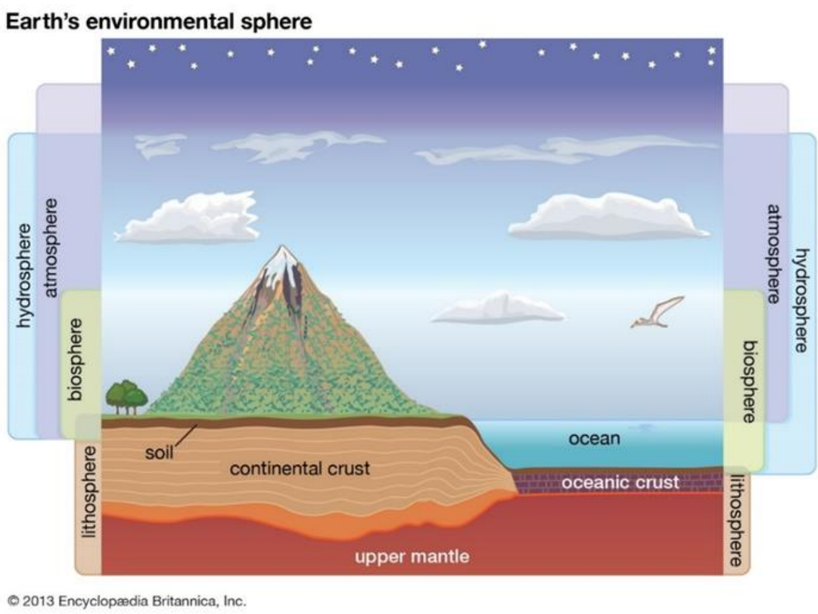


Fig 1.11 Earth's Environmental sphere

The 12 levels of organization in nature under Biosphere are as shown in table 1.1

Table 1.1 Levels of organization in nature

1. Biosphere	• Biosphere is a relatively thin life-supporting stratum of Earth's surface, extending from a few kilometres into the atmosphere to the deep-sea vents of the ocean. • The biosphere is a global ecosystem composed of living organisms (biota) and the abiotic (non-living) factors from which they derive energy and nutrients.
2. Biome	• A biome is a large region of Earth that has a certain climate and certain types of living things. Major biomes include **tundra**, forests, grasslands, and deserts. Plants and animals that live within smaller areas of a biome also depend on each other for survival. Each biome has many ecosystems.
3. Ecosystem	• An ecosystem consists of all the living things in an area together with the abiotic, non-living parts of that environment such as nitrogen in the soil or rain water. Example: Forests
4. Community	• A community is the sum of populations inhabiting an area. For instance, all the trees, flowers, insects, and other populations in a forest form the forest's community
5. Population	• Consists of all the individuals of a species living within the bound of a specific area
6. Organ **7. Organ System**	• A structure consisting of several tissues adapted as a group to perform specific functions, such as the heart. • Consists of several organs that work together in performing a specific function such as a circulatory system.
8. Tissue	• Group of cells which work together to perform a specific function
9. Cells	• Life's fundamental unit of structure and function
10. Organelles	
11. Molecules **12. Atoms**	• Atoms form molecules which are chemical structures consisting of at least two atoms held together by one or more chemical bonds • Atom is the smallest and most fundamental unit of all matter

The broad classification of Biomes in today's world is as follows:

1. Tropical Rain forest
2. Tropical Dry forest
3. Savanna
4. Desert
5. Temperate grassland
6. Temperate deciduous forest
7. Temperate Rain forest
8. Tundra

9. Alpine
10. Polar Ice

1.3 Linkages between UN Sustainable Development Goals and Waste Management

In September 2015, the United Nations General Assembly formally adopted the 2030 Agenda aiming for global action consisting of 17 Sustainable Development Goals (SDGs) and 169 associated targets.

Fig1.12 UN SDG goals

https://www.un.org/sustainabledevelopment/sustainable-development-goals/

The implementation of SDGs initiated since 2016 needs every country to meticulously plan, prioritize, and adapt the goals and targets in accordance with the local challenges, capacities and resources availability.

The 17 goals include the following:

a. No poverty

b. No hunger

c. Good health and well-being,

d. Quality education

e. Gender equality

f. Clean water and sanitation

g. Affordable and clean energy

h. Decent work and economic growth, industry, infrastructure, reduced inequalities,

i. Sustainable cities and communities, Responsible consumption and production,

j. Climate action, life below water, life on land, peace, justice and strong institutions and partnerships for goals.

Though these are not mandatory goals for countries, but each goal in a way if applied shall provide tangible benefits. India being a signatory to these goals is working on these goals and its targets set.

Which goals matters the most with regard to waste management?

As regard to waste management, the following goals are applicable:

a. SDG # 4 quality education – in the form of awareness and capacity building in waste management can be applied, clean water and sanitation
b. (SDG#6) which can focus on waste water and environmental hygiene and sanitation, affordable and clean energy
c. (SDG#7), here it can be applicable with regard to the generation of energy from waste.,
d. SDG #9 industry and infrastructure – applicable in terms of developing recycling canters, better infrastructure for waste management, sustainable cities and communities
e. (SDG #11) – it is applicable as waste management is an infrastructure necessity along with environmental and social connect, as cities have the major issues handling and disposing wastes . The efforts of communities through their attitude towards wastes connect its
f. SDG #11. SDG #12 goal of responsible consumption and production – is applicable as it works on sustainable consumption, valuing resources, produces more from less
g. SDG # 13 climate action – as waste disposal and treatment practices results in GHGs emissions, the goal 13 too is relevant to waste management.
h. SDG #14 – Life below water – since plastics menace is a problem both to marine and other aquatic life forms, this goal is relevant in waste management.
i. SDG #16 – Life on land is relevant as landfill, illegal dumping is a major targets for working.

1.4 Waste Movement -Cyclic vs Linear

The rapid industrialization and the increasing consumerism prevalent in society led to huge generation of waste and subsequent clearing by dumping in landfills or burning it in incinerators. The approach was known as linear system of movement of waste and the mantra was to get the waste out of sight by sophisticated handling equipment and dumping them out of city. Reaching the point of disposal at the earliest point of time was the key to this disposal.

Linear systems generally involved huge transport costs between the producer, consumer and point of disposal. The developing economies were finding it difficult to organize, buy and maintain such huge amount of machinery and transport vehicles. Over and above that the quantum of wet waste was high in these countries like India, leading to mixing with other wastes to be moved for landfills.

This way of disposal, prevalent for the last 100 years was becoming ineffective with its effect on the environment and the scarcity of resources. World-wide organizations, countries and government tried to investigate the re-use or re-cycle of the waste for better waste management. This re-use or re-cycle led to the revisit of the product again back to the starting point. This was the circular type of waste movement.

The key difference between Circular and Linear movement of waste are

- Circular systems use natural systems and enable the actual user to centralize and simplify their activities. It involves low-energy, low-technology, small scale, decentralised approach at the community (and possibly even individual) scale. It states that achieving this will involve Waste processing and Waste recycling activities. The usage of human capital helps create jobs and sustainable livelihoods

- The linear systems are intense, singular activities but tend to create negative environmental impacts by disrupting natural processes and overwhelming nature's capacity to absorb waste products and use them in productive processes. The system is current energy-intensive, high-tech, large-scale, centralised, institutionally managed approach side of the Continuum.

1.5 Innovative Techniques to Revert from Linear to Cyclic Management

The following concepts are simple, yet effective and innovative to ensure transport of waste back in cyclic mode of management

- Zero Waste, Zero Hazardous waste and Zero Packaging waste at the starting point: The awareness should be increased amongst residents in homes, offices, businesses, factories, campuses to ensure that the packaging received and shipped out should be fully recyclable. Say "No to non-recyclable material". Care should be taken for minimizing the usage of Hazardous waste and nuisance waste.

- Keeping Discards unmixed and utilization of wet waste locally: 'Wet' food wastes can be fed to animals, buried in garden pits or trenches for fertilizer. The recycle effortshould be done right at the local level and pressure released on the waste management bodies of government, cities, town and villages. Composting or biogas generation can be done at home, commercial, factory or institute level.

- Don't discard your profits and recycle and earn: Dry wastes can be recycled. It helps to keep paper, plastics and other wastes separate to get better value from the recyclers. This motivates the end user and the local re-cyclers to earn while keeping the village, town or city clean.

Reduction in Hazardous wastes by wise-purchase policies

- Buy only low-mercury tube lights, or use LED's or CFL's
- Specify only lead-free paints and pigments for own use or your products.
- No PVC folders, stationary or labels. PVC generates dioxins when burnt on roadside or in mixed-waste dump fires

Eliminate Thermocouple (EPS) – Nuisance waste

- Save the transport cost to recyclers, thermocouple being a bulky item.
- Insist on thermocole-free supplies to you
- Avoid it in your own packaging. Use bubble-wrap, paper-pulp instead
- Re-design Multi-layer packaging for recyclability: Post-consumer PE-Nylon-PP multi-films are not purchased or recycled because of widely different softening- and melting-points. All dumps are full of them. Change your packaging material or work with both suppliers and scrap buyers to avoid countrywide pollution.
- Bio-gas is the best option: To reduce the burden of LPG gas

Summary

The biodiversity and the balance of waste by utilizing it is a gift from mother nature to all living beings. The micro/mini and small organisms eat, grow and move through the soil and ensure clean water, clean air, healthy plants and moderated water flow. This is the unique nature of our environment to effectively utilize and have a zero wastage of its resources i.e the living and the non-living beings. At the start of the 21stcentury, all countries across the world realized the finite resources for supporting human beings on planet and the need for the planned usage of the resources. The management of waste, the multiple types of waste and the magnitude of waste requires a scale of operation which must be self-sustainable, generate energy and income for all sections of society.

Model Questions

1. What are the components of the ecosystem and how is the increase in waste impacting our ecosystem?
2. Explain the difference between the circular system and linear system of waste management. What are the advantages of a circular system?
3. Do you think there is an impact of waste on sustainable development? Illustrate with examples in the Indian context.
4. How is the waste being managed in your city/town/village currently? What are the challenges in the current system? Develop a case study to highlight the problems and suggest possible solutions to address the problems.

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Chapter 2 - Introduction to Waste Generation

Introduction

Waste generation is a natural product of urbanization, economic development, and population growth. As nations and cities become more populated and prosperous, offer more products and services to citizens, and participate in global trade and exchange, they face corresponding amounts of waste to manage through treatment and disposal.

World waste production is expected to be approximately 27 billion tons per year by 2050, one-third of which will come from Asia, with major contributions from China and India.

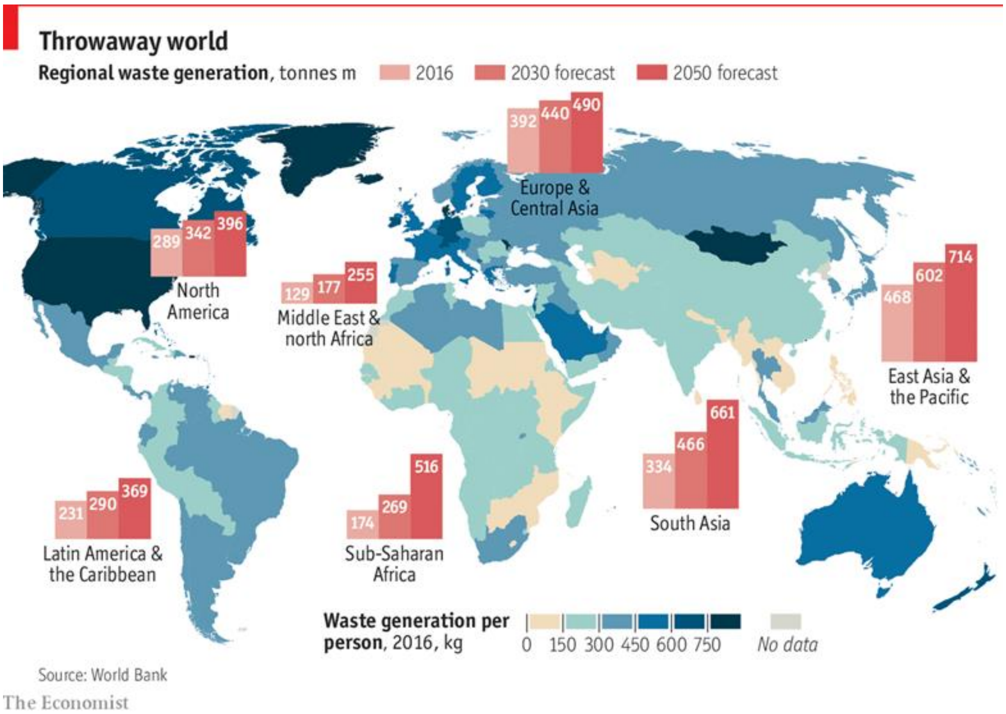

Fig 2.1 Waste generation worldwide in 2016

https://www.economist.com/graphic-detail/2018/10/02/global-waste-generation-will-nearly-double-by-2050

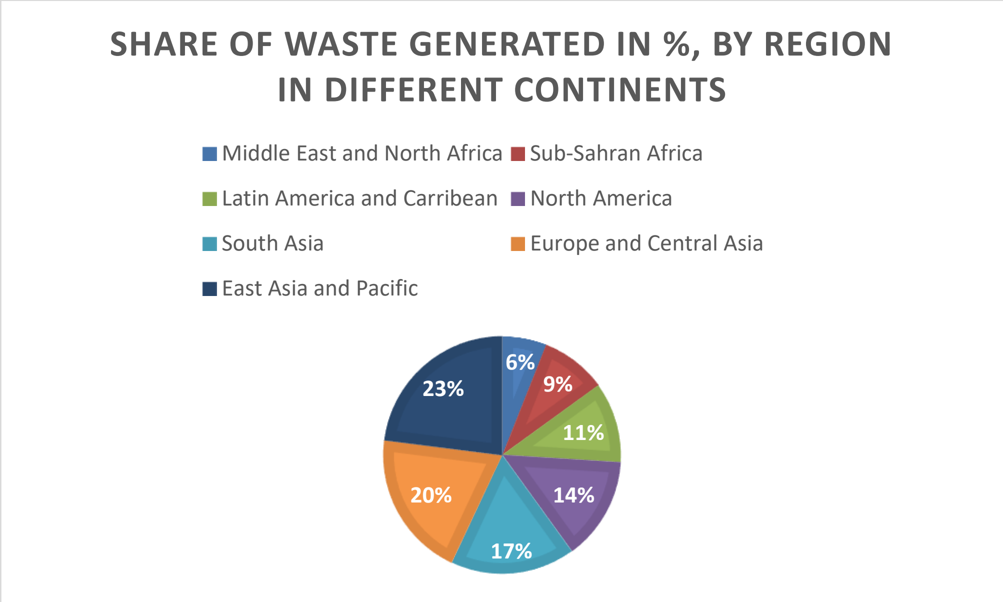

Fig 2.2 Percentage contribution of waste region wise

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Waste generation has been directly proportional to the rapidly growing GDP and economic progress of the countries. The rapid growth leads to consumeristic behavior and the society progresses through linear methodology of waste handling.

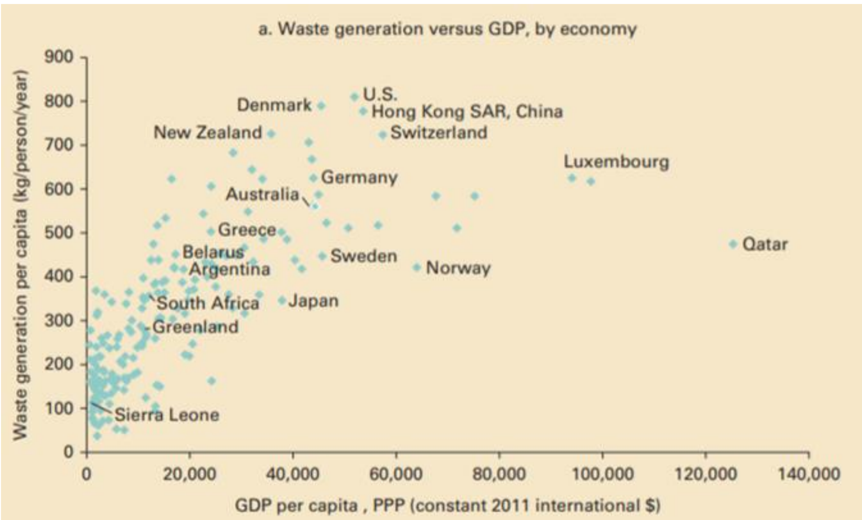

Fig 2.3 Waste Generation and GDP

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The urban areas are the highest waste generators and in India will be 0.7 kg per person per day in 2025, approximately four to six times higher than in 1999. The problems associated with waste become more acute as the population increases.

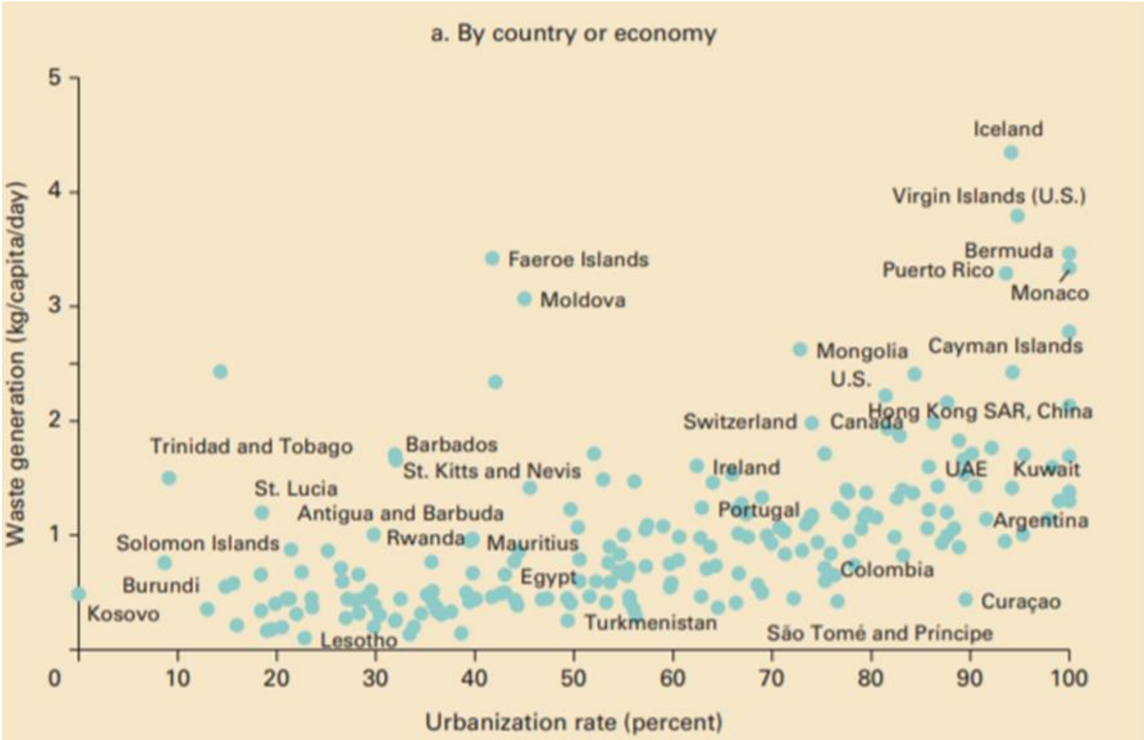

Fig 2.4 Waste Generation and urbanization rate

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India generates approximately 133760 tons of MSW (Municipal Solid Waste) per day, of which approximately 91152 tons is collected and approximately 25884 tonnes is treated. MSW generation per capita in India ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities. Waste is “anything that does not create value” (BSR, 2010). In a common man’s eye anything that is unwanted or not useful is garbage or waste. However scientifically speaking there is no waste as such in the world. Almost all the components of solid waste have some potential if it is converted or treated in a scientific manner.

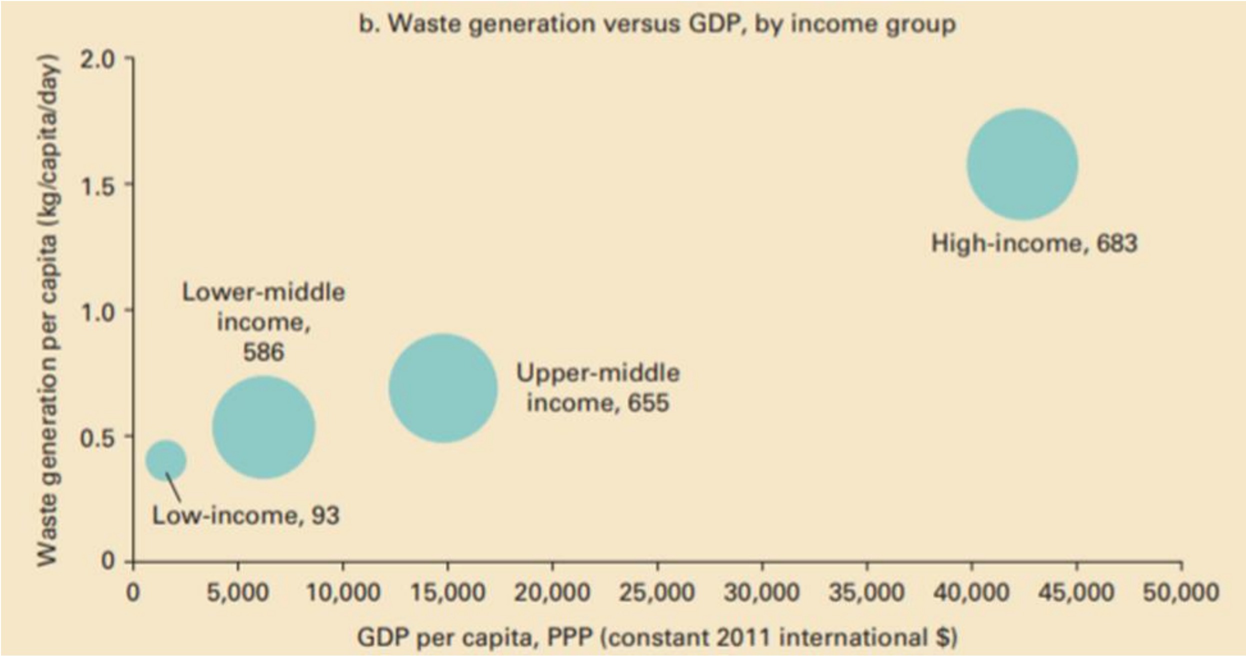

Fig 2.5 Waste Generation and income levels

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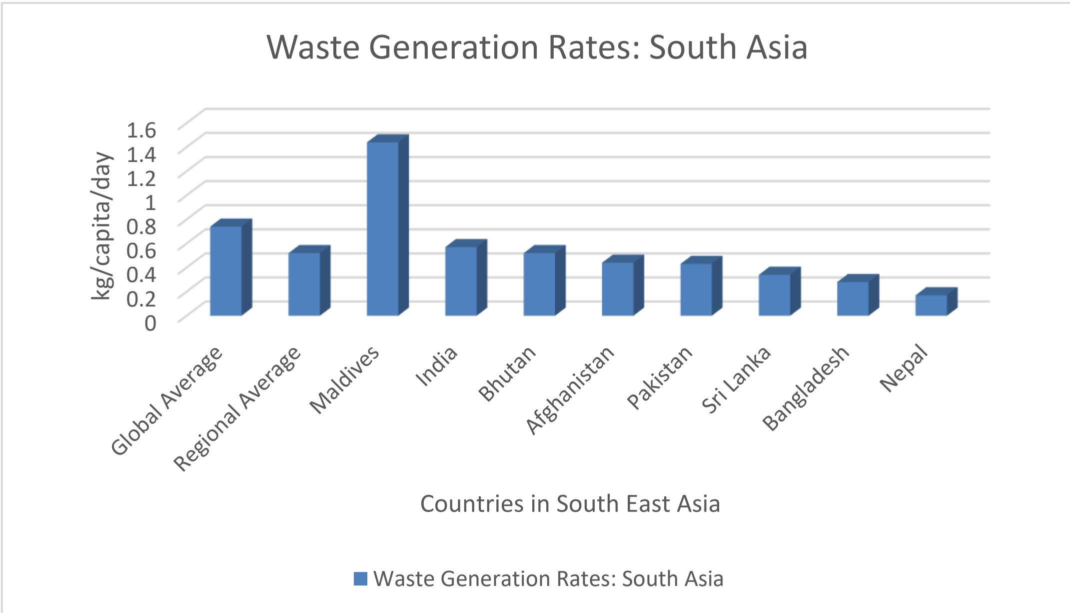

Fig 2.6 Waste Generation in South East Asia

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Hence, we can define solid waste as "Organic or inorganic waste materials produced out of household or commercial activities, that have lost their value in the eyes of the first owner but which may be of great value to somebody else." (Robinson, W.D.1986).

There are two main kinds of waste discarded. Organic Waste from cooked and uncooked food, fruit and flowers are natural products which decompose quickly and are called 'Wet' waste. Other manmade or manufactured products which are discarded are called "Dry' wastes. These include plastics, rubber, metal, glass, cloth, paper, and packaging. If all these different types of discards are kept unmixed, each of them can be reused or recycled if they are collected and managed separately and not mixed with each other.

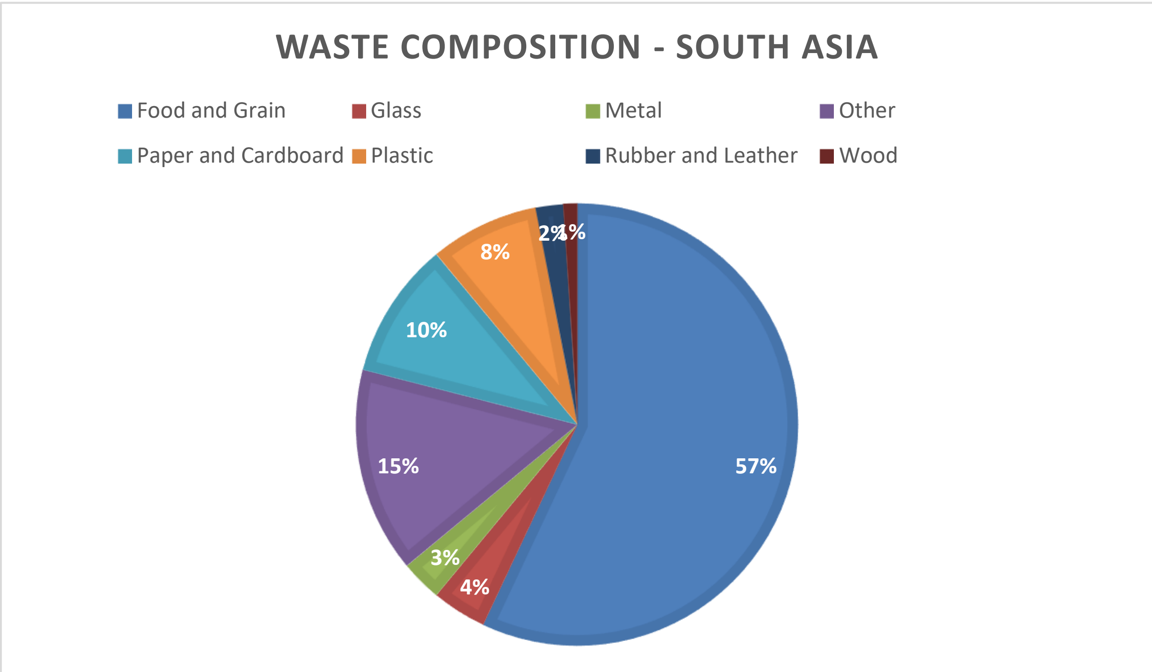

Fig 2.7 Waste Composition in South Asia

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Waste, if not properly managed, especially excreta and other liquid and solid waste from households and the communities, becomes a serious health hazard and leads to spread of several infectious diseases. Unattended waste dumped around attracts flies, rats, and other creatures that in turn spread disease.

Normally it is the wet waste that decomposes and releases a bad odour. This leads to unhygienic conditions and thereby, to a rise in health problems. Solid wastes include wastes such as product packaging, newspapers, office and classroom paper, bottles and cans, boxes, wood wastes, food scraps, grass clippings, clothing, furniture, appliances, automobile tyres, consumer electronics, and batteries. The waste generation is directly co-related to the GDP, the urbanization levels, income levels and exclusively have a regional flair.

Objectives

- Mapping the waste situation: globally and nationally
- Comparative analysis of the Waste handling mechanisms in the present and past
- Identifying reasons for the increase in waste quantity
- Explaining the Impact of excess waste generation
- Identifying the principles of waste management

2.1 Waste Around us

According to the Press Information Bureau, India generates 62 million tonnes of waste (mixed waste containing both recyclable and non-recyclable waste) every year, with an average annual growth rate of 4% (PIB 2016). The generated waste can be divided into three major categories: Organic (all kinds of biodegradable waste), dry (or recyclable waste) and biomedical (or sanitary and hazardous waste).

India is home to 1.21 billion people (based on 2011 Census) and the population has increased by almost 181.5 million (million) since the last decade. The population growth in India has been high and it grew by 22% during 1991–2001 and 18% in the last decade. The beaming economy of the Indian sub-continent has also resulted in a rapid change in the demographics of the country from a rural to an urban society with a fast pace of urbanization, due to which an estimated 600 million Indians will start living in urban areas by 2031. (As per estimations made under the 'Report on Indian Urban Infrastructure and Services – High Powered Expert Committee (HPEC).

As per a recent World Bank report estimates, ten years ago there were 2.9 billion urban residents who generated about 0.64 kg of municipal solid waste per person per day (0.68 billion tonnes per year), which, as of today, is estimated at 3 billion residents generating 1.2 kg per person per day (1.3 billion tonnes per year). By 2025, this will likely increase to 4.3 billion urban residents generating about 1.42 kg/capita/day of municipal solid waste (2.2 billion tonnes per year).

As per the 2011 census there are 7935 towns in India's 676 districts, of which 4041 are municipalities, corporations, cantonments or have notified area committees to be covered under the 'Swachh Bharat program'. There are also 475 large Urban Agglomerations (of more than one city/ town) plus 981 "Outgrowths" of over 20,000 population like railway colonies, university campuses, port areas or military camps. 415 Class 1 Cities of 1 - 10 lakh population generate 30 to 550 TPD of Municipal Solid Waste and have a total population of 104 million which is 28% of our urban population. 53 Cities have million-plus populations and a combined population of 161 million (42% of our total urban population). 3 of these are Mega cities of over 10 million population; Greater Mumbai, Delhi and Kolkata.The remaining 3894 are smaller "census towns", usually outside cities, withat least 5000 population and 75% of the male workforce not in agriculture.

As per the Central Pollution Control Board (CPCB) report (2012–13), municipal areas in the country generate around 170,000 metric tonnes per day (TPD) of municipal solid waste (annual generation of 62 million tonnes of waste).

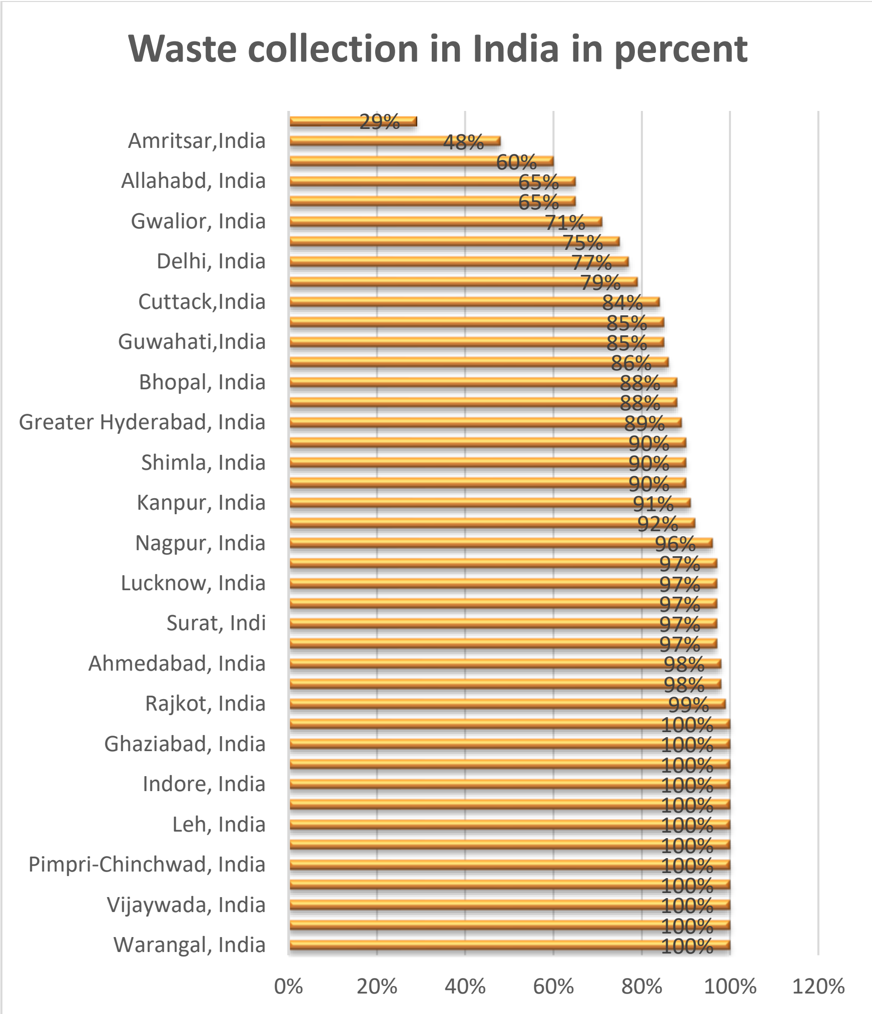

Fig 2.8 Waste collection rates for towns and cities in South Asia

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As per 2011 census, 31.16 % population (i.e. 377 million people) of India lives in 4,041 municipal authorities. It is estimated that by 2050, 50% of the population will be living in urban areas, and the volume of waste generation will grow by 5% per year. Accordingly, the expected waste quantity would be for the year 2021, 2031, and 2050 as - 101 mn metric tonnes per year, 164 mn metric tonnes, and 436 mn metric tonnes per year respectively.

2.2 Comparative Analysis of the Waste handling in the Present and Past

The following table gives us an idea of the different method of waste handling as it developed and spread all over the world.

Table 2.1 Methods of Waste handling across Ages

Vedic India	Zero-waste	Household wastes were fed to livestock or composted in backyard pits and returned to the soil every season. This practice continued while cities were small, with surrounding farmers bringing their produce to town and returning with city waste, for composting on their land
3000 B.C	First Landfill	The first landfill is developed when Knossos, Crete digs large holes for refuse. Garbage is dumped and filled with dirt at various levels.
2000 B.C. – China	Re-Cycling	Methods of Composting/Recycling, and recycling bronze for later use.
500 B.C. – Athens, Greece	Law	Claiming garbage must be dumped at least one mile from the city.
1200 -1700 Britain	Employment	Waste collectors were to simply to rake up the trash, into a cart, on a weekly basis. These men forged the way for the future of the garbage man
1388 Britain	Law	Bans dumping of waste in ditches and public waterways
1551 Germany	Packaging	Placing the paper in wrappers labelled with his name and address by Paper maker Andreas Bernhart. First recorded use of packaging
1350 Britain	Law	Law mandating a clean front yard.
1407 Britain	Law	Waste must be stored inside until rakers remove it
1700-1900 USA	Plants Coal Law Technology	Mass Burn Plants New Industrial Pollutant Public Health act of 1875 for authority for waste collection First incinerator in USA
1945 USA	Technology	Sanitary landfills
1956 Britain	Law	Clean air act stopping burning of waste to ashes
1920 to 1950	Technology	Rear Loader truck and the side loader truck.

While the above events were happening around the world, British India followed good hygienic practices for other wastes. Night soil from dry latrines was buried in trenches in rotation. Large "grass farms" outside cities naturally purified sewage through land application. Domestic waste was collected door-to-door in bullock-carts and sent to the outskirts of town for composting.

City garbage was mostly organic then, and unpolluted. Farmers used it on their fields to return nutrients and micro-nutrients to their soils before synthetic fertilizers became available. So, there was no need for large areas for treatment or disposal of MSW. All this changed when urea was subsidized and the Plastic Yug began. The Green Revolution changed the urban environment too.

Present

Key waste management legislations in India

Waste Management in India

As shown in Fig21, less than 60% of waste is collected from households and only 15% of urban India's waste is processed in a country 12 times as dense as that of the United States

(US) (PIB 2016)

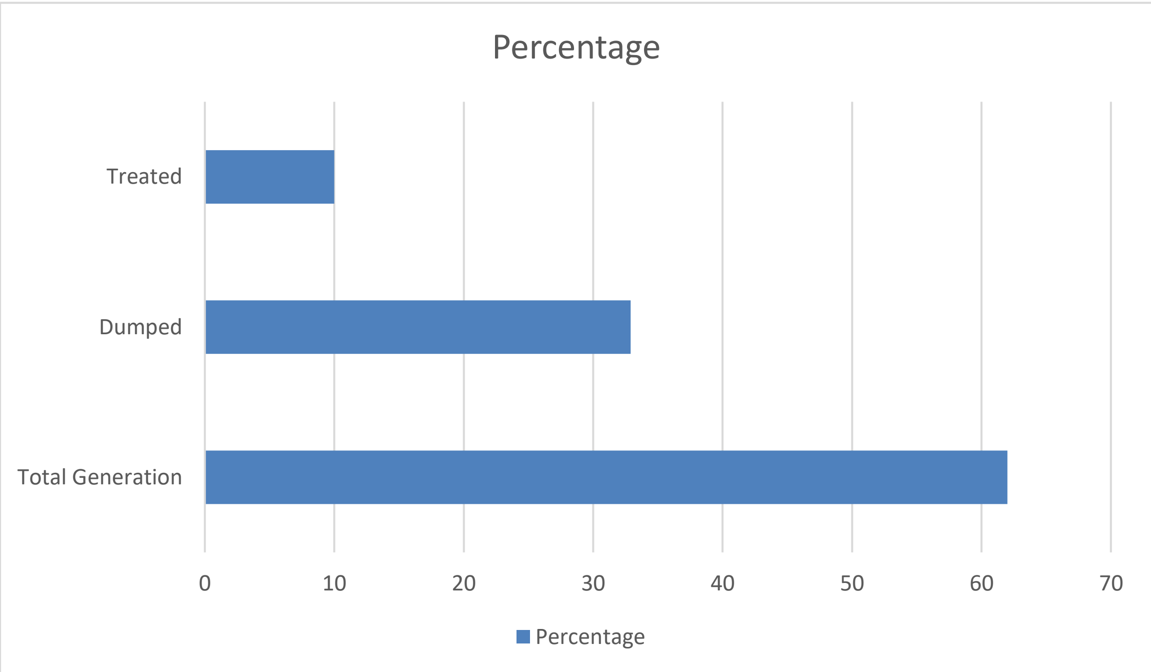

Fig 2.9 Waste collection in Indian household

US PIB 2016

While the collection rate needs to be improved to avoid illegal dumping and burning waste at street corners and unoccupied lands, what happens to the waste post-collection is the subject matter of focus of this section.

Process of Waste Collection and Dumping

Every Indian town has at least one specific area earmarked as a landfill area. As shown inFig22, the collection process begins with contractors employed by government bodies performing door-to-door collection services covering all households, scourging for any recyclables that may fetch a market price and later transporting all remaining waste to landfills. Each truck typically waits in line for two to three hours for its turn to weigh the amount of waste collected that day and then typically waits for some more time to dump the waste into the landfill. This process creates two perverse incentives:

- The contractor has an incentive to dump it illegally onto any vacant plots, to save on transportation costs from across the city to the landfill and to save time waiting at the landfill for his turn to dump.
- The contractor earns revenue proportional to tonnage of waste dumped. This perversely incentivizes him to dump more, resulting in existing landfills receiving an unmanageable amount of waste. This leads to open burning of waste to create space and the cycle of collection, dumping and burning goes on infinitely.

Fig 2.10 Process flow versus stake holders in the waste handling

The MoEF issued MSW (Management and Handling) Rules 2000 to ensure proper waste management in India and new updated draft rules have been enforced in 2016. Municipal authorities are responsible for implementing these rules and developing infrastructure for collection, storage, segregation, transportation, processing and disposal of MSW. Chandigarh is the first city to develop SWM in a planned way and has improved waste management compared with other Indian cities.

Role of the Informal Sector in Waste Materials Reuse and Recycling

- The informal sector has a very important role in India and this must be integrated into formal SWM systems. The informal sector is characterized by small-scale, labor-intensive, largely unregulated and unregistered low-technology manufacturing or provision of materials and services.
- Waste pickers collect household or commercial/industrial waste and many hundreds of thousands of waste pickers in India depend on waste for an income, despite the associated health and social issues.
- Pickers extract potential value from waste bins, trucks, streets, waterways and dumpsites. Some work in recycling plants owned by cooperatives or waste picker associations.
- Waste picking is often the only source of income for families, providing a livelihood for significant numbers of urban poor and usable materials to other enterprises. Waste pickers in Pune collect organic waste for composting and biogas generation. Waste pickers also make a significant contribution by keeping cities clean.
- A recent study of six Indian cities found that waste pickers recovered approximately 20% of waste, with 80 000 people involved in recycling approximately three million tons. It is estimated that every ton of recyclable material collected saved the ULB approximately INR 24 500 per annum and avoided the emission of 721 kg CO2 per annum.

Waste Collection and Transport

- Waste collection, storage and transport are essential elements of any SWM system and can be major challenges in cities.
- Waste collection is the responsibility of the municipal corporations in India, and bins are normally provided for biodegradable and inert waste. Mixed biodegradable and inert waste is often dumped, with open burning a common practice.
- Improvements to waste collection and transport infrastructure in India will create jobs, improve public health and increase tourism. Local bodies spend around Rs. 500–1000 per ton on SWM with 70% of this amount spent on collection and20% spent on transport.

Waste Disposal

- SWM disposal is at a critical stage of development in India. There is a need to develop facilities to treat and dispose of increasing amounts of MSW. More than 90% of waste in India is believed to be dumped in an unsatisfactory manner. It is estimated that approximately 1400km2 was occupied by waste dumps in 1997 and this is expected to increase in the future.
- Properly engineered waste disposal protects public health and preserves key environmental resources such as ground water, surface water, soil fertility and air quality. Indian cities with containment landfill sites include Mumbai, Kolkata, Chennai, Nashik, Vadodara, Jamshedpur, Allahabad, Amritsar, Rajkot, Shimla, Thiruvananthapuram and Dehradun .

2.3 Reasons for the Increase in Waste Quantity

The current generation is generating more waste compared to the older generations. The following are the reasons.

1. Consumerism:
2. Disposable income
3. Excess production- pushing goods into new markets.
4. Packaging
5. Changed attitude and lifestyle of the new generation
6. Globalization
7. Improper utilisation of resources, leading to wastes

To Do Activity
Film Analysis and discussion https://www.youtube.com/watch?v=jpf7lyxgy5I What are the problems being discussed in the film? What are the solutions being offered? What are your key learnings from the case study?

The root causes of mounting wastes are:

- Improper utilisation of resources, leading to wastes
- Inadequate waste disposal infrastructure and indiscretion in waste dumping
- Poor public participation in waste management
- Lack of responsibility towards waste in the community
- Lack of awareness in sustainable waste management systems

The local economy impacts waste composition. The affluent groups use more packaged products, resulting in higher volumes of plastics, paper, glass, metals and textiles. Municipal Solid Waste (MSW) may also contain hazardous wastes such as pesticides, paints, used medicine, batteries and plastic disposables. An important cause for increase in waste generation and management is general lack of awareness, knowledge, and attitude towards wastes.

More non-degradable materials are being invented and used. Consumption is being encouraged to meet mass-production. Excess disposable income encourages throwing away goods without fully utilizing them. Development of logistics (especially e-retail) and packaged food require proper packaging for safe and convenient transport. There is a vast geographical and social gap between the producers and the consumers, whereby the consumer cannot relate to the different aspects of production and the waste generated in the intermittent process.

Urea subsidies completely distorted nutrient application. Synthetic fertilizers get annual subsidies over Rs 14,000 crores. Just 12% of this subsidy is the one-time cost of compost plants for 300 cities! Organic manures are denied any subsidies worth Rs 227 on equivalent NPK basis, without the drought-proofing and water-holding benefits of its humus content and microbes that restore soil vitality, strengthen roots and reduce pest attacks. So, agricultural use of city waste declines, just when cities are growing exponentially.

The advent of plastic packaging, thrown away indiscriminately with kitchen wastes, made both types of waste unusable and unrecyclable. In fields it prevents germination and absorption of rain by the soil. Left uncollected in cities, it blocks drains, causes flooding, kills cows that eat garbage.Open dumping is ruining the lives of peri-urban villagers. Mixed urban waste, unwanted, now blights the outskirts of every Indian city. Wastes left to rot in airless heaps generate methane and catch fire. The smoke from such smouldering dumps is continuous and intolerable. Villagers are plagued with flies by day and mosquitoes by night, which breed in pockets of moisture within garbage heaps.

Stray dogs that feed and breed without a human touch, become feral (half-wild). They form hunting packs that kill hens and sheep by day and night, bite children especially, and spread rabies. They terrorise home-going farm-hands and two-wheeler riders, causing daily accidents, with school-going kids suffering the most injuries. It is vital for public health, for dogs to be declared VERMIN within compost-yards and land-fills and within a half-kilometer radius of open dumps.

2.4 Impacts of Excess Waste Generation

The impact of the waste dumping system that is legally practiced today is humungous—to human health, environment and the socio-economic well-being of an estimated two million waste-picker families who live off the dumping grounds today in India.

Effect on Human Health: The US Public Health Service has identified 22 human diseases that are linked to improper solid waste management (MIT Urban Development Sector Unit 1999). Several studies have been published that link asthma, heart attack, and emphysema to burning garbage. Human faecal matter is also frequently found in municipal waste—this, along with unmanaged decomposed garbage, attracts other rodents that further lead to a spread of diseases such as dengue and malaria (Biswas 2012).

Dumpyards are frequently known to catch fires – the one at Deonar in 2016, located in Mumbai (the most populated metropolitan city of India, with a population of more than 11.5 million people [Census Department, Government of India, 2017]), raged for three months, pumping tonnes of cancer-causing smoke into the air, caused by burning plastic, leather, etc. Holding waste equal to the height of an 18-ft tower, the dumping ground at Deonar has led to the areas surrounding Deonar to be classified as the city's most polluted suburb (based on data from the System of Air Quality and Weather Forecasting and Research [SAFAR]) (Times of India 2015).

Effect on Environment: Burning garbage is classified as the third biggest cause of greenhouse emission in India—apart from the impact on human health, the effect on land, water and food pollution is a matter of grave concern. Burning releases carbon monoxide, nitrogen oxide, Sulphur dioxide, and carcinogenic hydrocarbons, apart from particulate matter into the air, resulting in India releasing 6% of methane emissions only from garbage (compared to a 3% global average) (Planning Commission 2014). By 2047, it is expected that 1,400 sqkm of landfill area would be required for dumping India's increasing volumes of municipal solid waste; this space is roughly equal to the combined area of three out of top five most populous cities in India: Hyderabad, Mumbai and Chennai (Annepu 2012). Leachate from rotten garbage contains heavy metals and toxic liquid; with such emissions ending up either absorbed into the soil or flowing into water bodies today (Awasthi

2013), the entire food chain can be affected when this contaminated water is utilized for agriculture, human consumption and animal consumption.

Effect on Waste-Picker Families: An estimated two million waste-pickers exist in India today (Chaturvedi 2010); these are families that live off dump yards through collection and sale of recyclables from the dumped mixed waste. While some estimates state that nearly 40% of the waste-pickers are children aged below18 years, what is definite is that these families live off in unhygienic environments, succumbing to malnutrition, extreme poverty, and adverse health infections. With no physical protection such as gloves, uniforms, shoes or masks, most children scourge for metals with magnets attached to sticks, thus putting their health to extreme risk. Not only do the landfills emit methane that is approximately 21 times as potent as carbon dioxide (OECD), toxic leachate continuously flows out, making dump-yards susceptible to natural and artificially caused fires, hence putting the lives of waste-picker families at risk. These families are also recorded to be affected by several respiratory diseases, physical cuts, worm infestations, and skin diseases (Hunt 1996).Waste generated creates awful smell, also has an adverse effect on resources, if it is not treated properly. Excessive waste generation pollutes air, water and soil, if not handled properly. This will damage the health of individuals and also damage the ecosystem. The increase in volume of waste is not limited to domestic waste, but also spreads to residential, commercial, institutional, and industrial waste which leads to piling up of mounting wastes.

Occupational Hazards Associated with Waste Handling Infections

- Skin and blood infections resulting from direct contact with waste, and from infected wounds.
- Certain chemicals if released untreated, e.g. cyanides, mercury, and polychlorinated biphenyls are highly toxic, and exposure can lead to disease or death.
- Eye and respiratory infections resulting from exposure to infected dust, especially during landfill operations.
- Many diseases are caused by the bites of the flies and mosquitoes, feeding on the wastes.

Chronic diseases

Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds.

Accidents

- Bone and muscle disorders resulting from the handling of heavy containers. Infected wounds result from contact with sharp objects.
- Poisoning and chemical burns resulting from contact with small amounts of hazardous chemical waste mixed with general waste.

2.5 Identifying the Principles of Waste Management -Waste Disposal vs Waste Management

1. 4Rs: Refuse, Reduce, Reuse & Recycle

2. Segregation at source: Store organic or biodegradable and inorganic or non-biodegradable solid waste in different bins. Recycle of all the components with minimum labor and cost.

3. Different treatments for different types of solid wastes: One must apply the techniques which are suitable to the given type of garbage. For example: the technique suitable for general market waste may not be suitable for slaughter house waste.

4. Treatment at nearest possible point: The solid waste should be treated in as decentralized manner as possible. The garbage generated should be treated preferably at the site of generation i.e. every house.

Fig 2.11 4 R's – Principles of waste management

Summary

India generates 62 million tonnes of waste (mixed waste containing both recyclable and non-recyclable waste) every year, with an average annual growth rate of 4% (PIB 2016).

India is home to 1.21 billion people (based on 2011 Census) and the population has increased by almost 181.5 million (million) since the last decade. The population growth in India has been high and it grew by 22% during 1991–2001 and 18% in the last decade. The beaming economy of the Indian sub-continent has also resulted in a rapid change in the demographics of the country from a rural to an urban society with a fast pace of urbanization, due to which an estimated 600 million Indians will start living in urban areas by 2031. Urgent measures need to be taken to address the problem of waste in the country.

Model Questions

1. What are the hazards of waste on human health and environment?
2. Write an essay on the reasons for the increase in waste quantity and what can be done to reduce the generation of waste at a personal level?
3. Develop a business model of waste management for your city/town /village applying the principles of waste management.

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Chapter 3 - Waste characterization

Introduction

Waste composition is the categorization of types of materials in municipal solid waste. Waste composition is generally determined through a standard waste audit, in which samples of garbage are taken from generators or final disposal sites, sorted into predefined categories, and weighed. At an international level, the largest waste category is food and green waste, making up 44 percent of global waste. Dry recyclables (plastic, paper and cardboard, metal, and glass) amount to another 38 percent of waste.

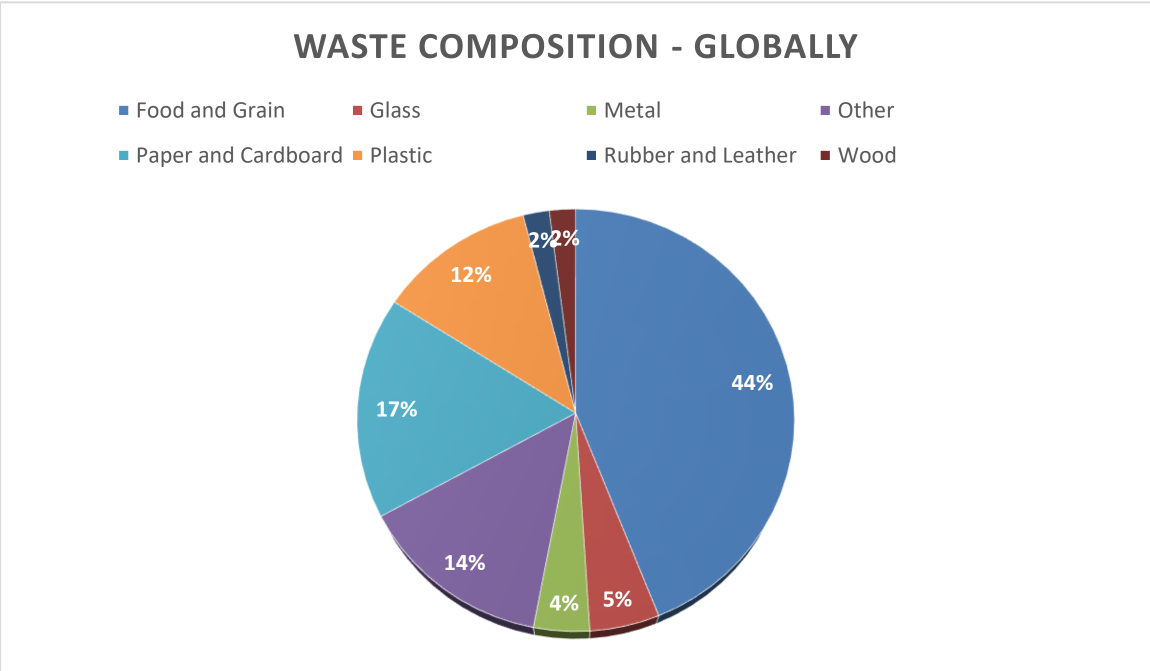

Fig 3.1 Waste composition on a global scale

Waste composition varies considerably by income level. The percentage of organic matter in waste decreases as income levels rise. Consumed goods in higher-income countries include more materials such as paper and plastic than they do in lower-income countries. The granularity of data for waste composition, such as detailed accounts of rubber and wood waste, also increases by income level and global food loss and waste accounts for a significant proportion of food and green waste.

The waste composition is a way of classification to understand the product before it became a waste. However, after becoming a waste the attributes relevant to the waste handling and processing are the following:

1. High Heating Value
2. Moisture
3. Proximate Analysis:
4. Ultimate Analysis
5. Physical Composition
6. Thermal Weight Loss behavior

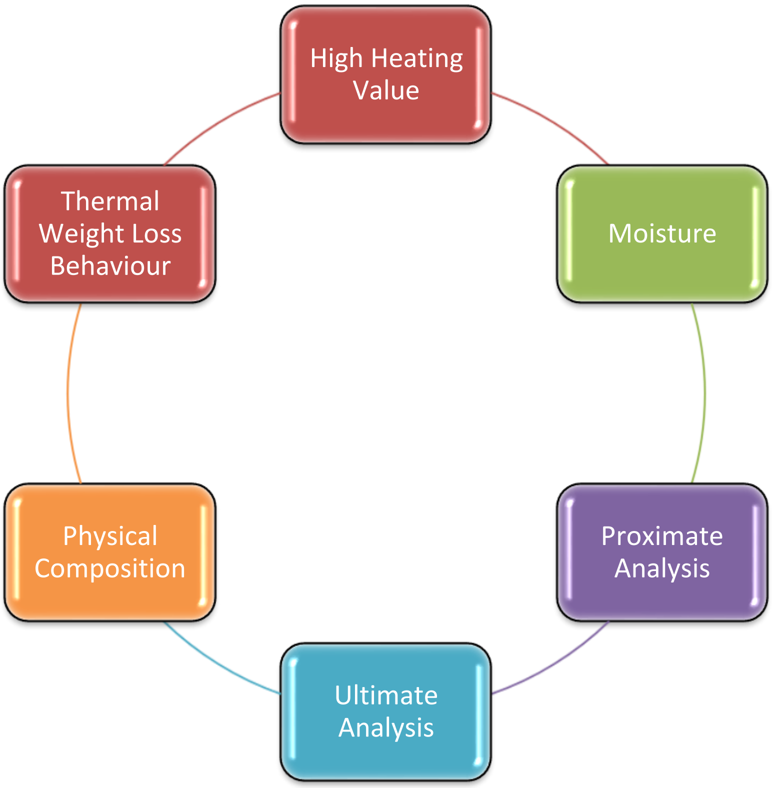

Fig 3.2 Waste attributes for processing or recycling

Objectives

3.1 To explain waste characterization.

3.2 To identify the sources of waste

3.3 To list down the types of waste

3.4 To recall the techniques for reducing waste segregation

3.5 To list down other wastes such as next generation waste, laboratory waste, festival non-routine waste

3.1 Waste Characterisation

Waste characterization process involves collecting, sorting and categorizing waste in order to obtain a statistical representation of the quantity of waste and their disposal methods.

The local economy impacts on waste composition, as high-income groups use more packaged products, resulting in higher volumes of plastics, paper, glass, metals and textiles. Changes in waste composition can have a significant impact on waste management practices. MSW may also contain hazardous wastes such as pesticides, paints, used medicine and batteries. Also based on category of products - waste characterization can be done. These include the following:

1. **Consumer Products** These materials come from everyday single-use or consumer non-durable products and include paper, packaging, food waste, plastics, containers, etc.
2. **Durable Goods**: This category consists of tools and objects that last a long time, such as furniture, appliances, electrical equipment, computers, electronics, etc. They are often disposed of separately from everyday consumer products but can nonetheless introduce a bias into the characterization as they are placed in the trash sporadically, not on a regular basis.
3. **Construction/Renovation/Demolition (CRD) or Construction and Renovation (C&D) Wastes:** Waste generated from building project. This cannot be included in consumer products waste. This one too is not on a regular basis.
4. **Hazardous Materials:** These wastes depending on the applicable rules and regulations are subjected to special methods of disposal. Hazardous materials include batteries, fluorescent tubes and chemical products, paints and solvents containers, refrigerants, cleaning agents, motor oil and propane cylinders. Hazardous materials should never be placed into regular trash, but instead recovered by specialized firms that will recycle or properly dispose of the material.

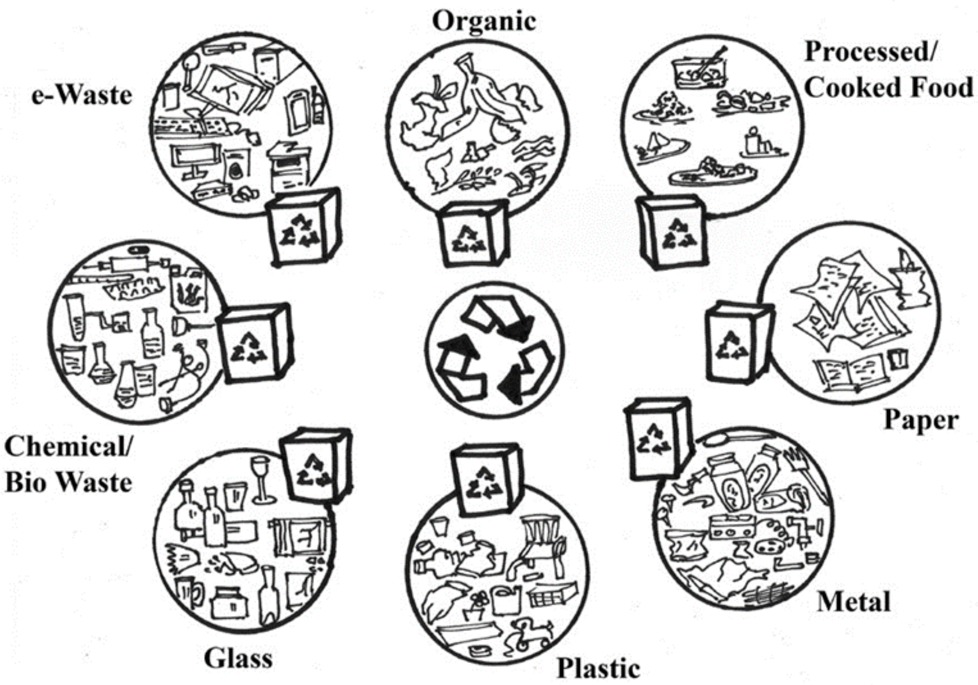

Fig 3.3 Waste characterization based on category of products

One of the most important responsibilities in waste characterization is identification of the waste collected, to conduct follow-up on the origins of waste and to obtain a precise idea of the situation and plan waste management accordingly.

The most common method for tracing waste is to label garbage bags and the wastes - wet and dry wastes. Each bag collected thus has a unique profile, and the waste can be analysed in terms of means of collection, collection site and periods of the day/ week. Labelling must contain the following minimum information:

- Day and time of waste collection;

- Collection site
- The means of collection (garbage bag, recycling bin, and its category, if applicable)
- Maintenance and collection personnel

To do Activity
Film analysis and discussion
What are the problems being discussed in the film?
What are the solutions being offered?
What are your key learnings from the film?
https://www.youtube.com/watch?v=MYrxgt2OwN8

Table 3.1: Categories and Sub-Categories of Wastes Characterization

Categories	Sub-Categories
Refundable aluminium containers	
Non-refundable aluminium containers	
Wood	Engineered wood
	Lumber
Cardboard boxes and cartons	Shipping boxes
	Corrugated cardboard
Aseptic packaging (laminated containers)	
Construction, Recovery and Demolition Waste	Plasterboard - Brick - Stone - Cement - Metal - Cables and wiring - Asphalt - Asphalt shingles - Construction lumber - Carpeting and floor coverings
Durable goods waste	Office furniture - Furniture - Appliances - Television sets - Computers - Monitors and screens - Partitions - Shelving, filing cabinets, bookcases - Air conditioners, ventilators, auxiliary heaters - Cell phones
Ferrous metals	
Compostable material	Paper towels - Starch-based biodegradable containers and bags

Hazardous Material	Unwashed containers of dangerous products - Chemical products - Pressurized containers (propane, butane, etc.) - Explosive material - Combustive material - Oil and gas products - Products containing asbestos or PCBs
Spoilable waste	- Table scraps - Green waste /Gardening waste
Recyclable paper	Office stationery - Wrapping paper /Kraft paper - Newspapers - Paper cups for water and coffee - Shredded paper
Plastic packaging, wraps	- Plastic bags - Food wrappings
Hazardous material	- Batteries - Electronics - Incandescent, Fluorescents bulbs - Ink cartridges
Refundable plastic containers	PET #1
Non-refundable plastic containers	PET #1 HDPE #2 PVC #3 PEbd #4 PP #5 Others #7
Non-recyclable plastic	Polystyrene for food products (#6 plastic) - Protective polystyrene (#6 plastic)
Glass containers	
Biomedical	Tubings, pipes, cotton, swabs, needles, syringes, medicines, anatomical wastes, bandages etc.

3.2 Sources of Waste

Solid waste can be classified into different types depending on their source:

a) Municipal Waste includes household waste and market waste. Municipal solid waste consists of household waste which now includes e-waste also, construction and demolition waste, sanitation waste and waste from sweeping streets. This waste is generated mainly from residential and commercial complexes. With changes in lifestyle, there has been rapid increase in amount of garbage and its composition changing drastically. More than 25% of the municipal solid waste is not collected at all; 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste.

b) Hazardous Waste

Industrial waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous like old batteries, shoe polish, paint tins, old medicines and medicine bottles. Hospital waste contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure and old medicines.

c) Biomedical Waste

It is also called as hospital waste and is infectious in nature. Waste from hospitals, diagnostic laboratories, clinics, healthcare facilities. Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities in these fields or in the production or testing of biologicals. It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner.

d) E-Waste

Electronic Waste, also called e-waste, refer to various forms of electric and electronic equipment that have ceased to be of value to their users or no longer satisfy their original purpose. Electronic waste (e-waste) products have exhausted their utility value through redundancy, replacement, or breakage and include both "white goods" such as refrigerators, washing machines, and microwaves and "brown goods" such as televisions, radios, computers, and cell phones. (Gitanjali Nain Gill, 2011).

e) Agricultural Waste

Agricultural wastes are an output of production and processing of agricultural products containing material that can benefit man, but whose economic values are less than the cost of collection, transportation, and processing for beneficial use.

- Organic wastes
- Used pesticide bottles
- Excessive fertilizer (NPK) in surface runoff

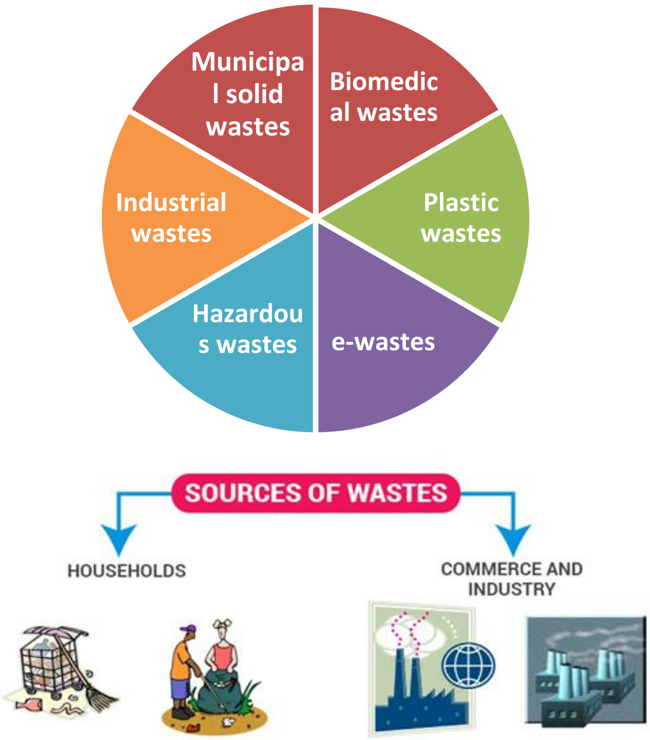

Fig 3.4 Sources of Waste

3.3 Types of Waste

Commonly waste is classified into two types: Biodegradable and Non-biodegradable waste. These two kinds of wastes are explained below:

Fig 3.5 Types of waste

Biodegradable Waste

These are the wastes that come from our kitchen and it includes food remains, garden waste, etc. Biodegradable waste is also known as moist waste. This can be composted to obtain manure. Biodegradable wastes decompose itself over a period of time depending on the material.

Non-biodegradable Waste

These are the wastes which include old newspaper, broken glass pieces, plastics, etc. Non-biodegradable waste is known as dry waste. Dry wastes can be recycled and can be reused. Non-biodegradable wastes do not decompose by themselves and hence are major pollutants.

Overview of Different Categories and Sub-Categories of Waste that can be used in the Characterization

Table 3.2 Categories of Waste and approximate time it takes to generate

Type of litter	Approximate time it takes to degenerate
Organic waste such as vegetable and fruit peels, leftover foodstuff, etc.	a week or two
Paper	10–30 days
Cotton cloth	2–5 months
Wood	10–15 years
Woolen items	1 year
Tin, aluminium, and other metal items such as cans	100–500 years
Plastic bags	one million years?
Glass bottles	undetermined (but it’s not harmful as plastics)

Table 3.3 Source, Facilities /Locations where Waste is Generated and Types of Wastes

Source	Typical Facilities, Activities, or Locations where Wastes are Generated	Types of Solid Waste
Agricultural	Field and row crops, orchards, vineyards, diaries, feedlots, farms, etc	Spoiled food wastes, agricultural wastes, rubbish, and hazardous wastes
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc.; non-industrial waste including food waste, rubbish, ashes, demolition and construction wastes, special wastes, and hazardous waste.
Commercial and Institutional	Stores, restaurants, markets, office buildings, hotels, auto repair shops,	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes, etc.
Municipal solid waste	Includes residential, commercial and institutions	Special waste, rubbish, general waste, paper, plastics, metals, food waste, etc.

3.4 Solid Waste Management Tools – Techniques for Reducing Waste Segregation and Scientific Disposal

Recycling of Waste

Recycling of waste product is very important as this process helps in processing waste or used products into useful or new products. Recycling helps in controlling air, water, and land pollution. It also uses less energy. There are a number of items that can be recycled like paper, plastic, glass, etc. Recycling helps in conserving natural resources and also helps in conserving energy. Recycling helps in protecting the environment as it helps in reducing air, water, and soil pollution.

Decomposition of Biodegradable Waste

Biodegradable waste can be decomposed and converted into the organic matter with the help of different processes.

Composting

This is the method in which waste can be decomposed and converted into organic matter by burying them in the compost pits. The wastes are composed by the action of bacteria and fungi.

Vermicomposting

This method involves decomposition of organic matter into fertile manure with the help of red worms. This manure is known as vermicompost.

3.5 Other Types of Waste

The following wastes are special waste and needs handling by specialized government agencies:

Radioactive Waste

Radioactivity is defined as the property possessed by some elements of spontaneous emissions of alpha particles (α), beta particles (β), or sometimes, gamma rays (γ) due to disintegration. Radiation from alpha particles loses energy very quickly when passing through matter. As a result, alpha particles travel only a few inches in air and can easily be stopped by the outer layer of human skin. But they are harmful to humans if they are ingested and can damage body organs specially the lungs.

Beta radiation travel farther as compared to alpha radiations. These can penetrate several layers of human skin. The human body can be damaged by exposure to a source of beta radiation or by ingesting it. Beta radiation can be stopped by an aluminium foil at least 2 mm thick.

Gamma radiation has a much smaller wavelength and can therefore penetrate much deeper. It can pass completely through the human body damaging cells or can be absorbed by tissues and bones. Damage to human health is therefore much larger. At least three feet of concrete or two inches of lead are required to stop 90% of the typical gamma radiation.

The process of unstable nuclei giving off radiation to reach a stable condition is called radioactive decay. Isotopes of elements having atomic number larger than 83 (Bismuth) are radioactive. A few elements with lower atomic numbers, such as potassium and rubidium, have naturally occurring isotopes which are also radioactive. Radioactivity is measured in terms of curie (Ci), which is defined as the quantity of a radioactive material in which the terms of number of disintegrations is 3.7 x 10 10 per second. Each radioactive element has a characteristic speed of decay, is called the half-life of the element.

The biological effect of radiation is measured in units called rems. A rem is the amount of beta or gamma radiation that transfers a specific amount of energy to a kilogram of matter.

Some instruments used in the detection of radiation include:

(i) Geiger Mueller Counter
(ii) Ionization Chamber
(iii) Scintillation Counter
(iv) Film Badges
(v) Thermo luminescent Dosimeter (TLD)

The Geiger Muller Counter, Ionization Chamber and Scintillation Counter are used for detection of surface contamination. Film badges and TLDs are used for long term monitoring of exposure to workers. Gamma Ray Spectroscopy is also used for analysis of gamma radiations.

Classification of Radioactive Wastes

Radioactive wastes or Low-level Radioactive Wastes (LLRW) is a general term used for a wide range of materials contaminated with radioisotopes. LLRW may be disposed on specially designed landfills.

These include wastes which are potential hazards and will persist long after such precautions as institutional controls, improved waste forms and deeper disposal have ceased to be effective. Radioactivity in the environment comes from both natural and man-made sources. Natural sources are natural deposits of radioactive materials such as uranium and thorium. Man-made sources include mining activities, nuclear power plants, medical and laboratory facilities, nuclear weapon testing etc.

Table 3.4.Overview of Classes A, B, and C for Radioactive Wastes

Characteristics	**Class A**	**Class B**	**Class C**
Concentration	Low concentrations of radionuclides	Higher concentrations of radionuclides	Highest concentrations of radionuclides
Waste form	Does not require stabilization but may be stabilized	Requires stabilization for 300 years	Requires stabilization for 300 years or more
Intruder Protection	Decays to an acceptable levels requires no additional measure to protect	Waste recognizable requires stabilization	After 500 years, decays to acceptable levels Required stabilization and deeper disposal or barriers
Segregation	Class A must be segregated from B and C	No need to segregate from Class C	No need to segregate from Class B
Waste Types	Protective clothing, paper, laboratory trash	Resins and filters from nuclear power plants	Reactor components high activity industrial waste

Disposal of Radioactive Waste

Management of radioactive waste includes various operations similar to the MSW e.g. transportation, processing and disposal. But the techniques adopted for such wastes are different. Cementation, Polymerization, Vitrification, and Land Disposal are the common techniques for hazardous waste management. Another techniques is Hold-for-decay disposal i.e. storage of radioactive wastes to allow decay of short-lived radionuclides to low levels so that wastes can be disposed off safely.

Land disposal of radioactive wastes is carried out both in the below ground vaults (BGV) and above ground vaults (AGV). A vault is an engineering structure built to hold the most hazardous low-level radioactive wastes such as Class C waste. Earth-mounted Concrete Bunkers (EMCB) is also used for land burial of radioactive wastes. It involves isolating the waste in an engineered vault located above or below the ground. A multilayer earthen cover is positioned over the vault to provide an additional barrier to the nuclear radiations.

Fly Ash

Fly ash is a major by-product in the coal-based thermal power plants. It is a finely divided residue resulting from the combustion of coal in a thermal power plant. It is generally grey in colour, abrasive, acidic, refractory in nature and has fineness (specific surface) of 4000 to 8000 sq. cm per gram. The particles range in size from as much as 120 to less than 5 microns in equivalent diameter. The part of ash that falls to the bottom of the boiler during combustion is called bottom ash, which is coarser in size and is washed away with water. Ash, which is fine and is carried away with flue gases, is called as "fly ash". It is separated from hot gases in the electrostatic precipitators of cyclone separators, from where it is carried away by wet method (slurry form) or by dry method. A portion of the fly ash escapes along with the hot gases through chimneys. Approximately, fly ash accounts for about 80 percent of the total ash produced.

Fly ash, being light in weight, gets airborne very fast and pollutes the atmosphere. Long inhalation causes silicosis, fibroses of lungs, bronchitis etc. It corrodes structural surfaces and its deposition damages horticulture and agriculture. Slurry disposal lagoons or settling tanks become source of mosquitoes and bacteria. Further, these have potential to contaminate the subsurface water with traces of toxic meals present in fly ash. Disposal of fly ash in the sea also disrupts the aquatic life cycle. Since the fly ash has severe environmental consequence it should be disposed of carefully.

Fly Ash Disposal

Disposal of fly ash is carried out in ash ponds. Ash is transported from the thermal power plants to the ash ponds thorough pipelines in the form of slurry. Fly ash can also be utilized in various construction and manufacturing operations. A great deal of literature is available on the utilization of fly ash especially as a construction material. Some of these are as follows:

Backfilling: Fly ash can be used in backfilling of open-cast mines. This avenue is very promising for ash utilization particularly if the thermal power plants are located near the mines. Fly ash can also be used in filling up of low-lying areas, for reclaiming land, and for construction of road embankments. Up to about 95 percent of maximum dry density can be achieved if controlled filling is carried out.

Blended cement: Being rich is silica and due to presence of pozzollons fly ash can be used either as a raw material for production of cement clinker or blended with finished cement. About 10 to 25 percent of dry fly ash can be mixed with clinker during manufacture of cement or blended with ordinary portland cement to produce Portland pozzolana cement.

Fine aggregate: Pond ash has particles size about the same as fine sand. It can therefore be used as a partial or complete replacement of sand in concrete. The mix design required for such concrete is somewhat different from that of the normal concrete.

Bricks, blocks and other products: Fly ash can be used as a raw material for the manufacture of fired clay bricks. Fly ash blocks can be used in the construction of pavements or for other purposes by adding appropriate amount of coarse aggregate to the mix e.g. mortar used for plastering of walls. Other applications include use of fly ash as a filler material in polymer composites which is a construction material.

Other important factors include pH of groundwater and the soil and the pesticide content etc. The depth of water table and vadoze zone and moisture content of soil are also important parameters. Climatological factors e.g. the ambient air temperature, rainfall etc. is also considered. Chemicals present naturally in soil e.g. chlorides, sulfates, carbon, nitrogen and the profile of various nutrients and metals present at the site should be analyzed before selecting a particular remediation technique.

The nature and characteristics of contaminant in the soil should be estimated. This includes identification of organic and inorganic fraction, volatile, semi-volatile, and non-volatile fraction; halogenated or non-halogenated compounds; metals especially heavy metals present in the contaminant. Some contaminants may be predominantly hydrocarbons e.g. due to oil spillage, leakage in petrol pumps. Other important considerations in deciding the techniques for remediation are solubility and biodegradability of contaminants. Finally, the volume and toxicity of such contaminants is always important.

A geotechnical or environmental engineer should also be aware of the legal requirements and guidelines to be followed for any remediation work in terms of the goals to be achieved. These goals are usually specified as:

a. In terms of the permissible limits of contaminants in the soil;
b. In terms of permissible limits of site where the wastes are to be disposed off; or
c. In terms of the technique employed e.g. disposal on secure landfills

Summary

Waste characterization process involves collecting, sorting and categorizing waste in order to obtain a statistical representation of the quantity of waste and their disposal methods. Commonly waste is classified into 2 types: biodegradable and Non-biodegradable waste. Another classification of waste is done based on the source such as municipal waste, biomedical waste, plastic , industrial waste , hazardous waste and e-waste. Scientific techniques of waste managing waste include recycling, decomposition, composting and vermicomposting. Radioactive waste fly ash is special waste and need handling by specialized government agencies

Model Questions

1. What is the difference between the nature of waste in urban and rural areas?
2. Who are the key stakeholders in waste management and what are the current challenges faced at different levels of waste management collection , segregation and disposal ?
3. Does recycling help in conserving natural resources ? How does it help in reducing water, air and soil pollution?
4. What can be the role of citizens in waste management ?

References

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Chapter 4 Source Reduction and Waste Disposal Practices

Introduction

The growing consumerism and globalization promote and cause huge consumption of products, goods and services to generate growth in the economy. This creates a huge amount of waste generation or disposal of unused/not required products.

A sound waste management plan is about the prevention of the waste generation at the first place i.e. a more pragmatic approach classifying reduction strategies on a waste management hierarchy with focus at the first step. The first stage in the pyramid is source reduction followed by recycling, waste to wealth creation and the last one is the disposal.

Objectives

By the end of the chapter the students will be able to:

- Explain Source reduction
- List down the waste reduction strategies and their economic benefits
- Explain source reduction vs waste reduction
- Analyze the present scenario of solid waste management in Urban and rural areas
- list down the waste disposal practices

4.1 Source Reduction – Waste Prevention

To solve the problem of waste we need to first work to reduce the consumerist behaviour and huge consumption of items by segments of society. The measures taken before a substance, material or product has become waste are defined as waste prevention measures.

Source reduction benefits the society and the ecosystem in the following ways:

a. Reduces the quantity of waste
b. Extends the life span of products
c. Reduces adverse impacts on the environment and human health
d. Prevents exposure to harmful substances that may release on the breakdown of products
e. The cost of waste management is reduced
f. Reduction in ecological footprint

The requirement to change a habit or lifestyle and promoting source reduction is easier said than done. The challenges of source reduction are as follows:

a. A lack of knowledge about effective strategies to be deployed with respect to aneco-system.

b. Assessment of a preventive action is challenging which results in implementation of source reduction difficult to practice and quantify.

   Several organizations around the world are now developing a consistent and comprehensive approach to help local and regional authorities to popularize source reduction.

c. Reducing consumption contradicts people's perception of high-living and feel good factor of a growing consumerist society. They are unwilling to compromise on their lifestyles.

d. Fear that Source reduction practices will slow down the economy and the country's development.

Contrary to all perceptions prevalent in society, the ground reality is that source reduction alone can provide long term economic growth for a nation or an individual.

Source reduction is sustainable as it allows a country/ecosystem/economy to effectively manage the fixed (depleting) natural resources by reusing or recycling them.

An example of the waste source and products provided below shows how reusing the items of daily use by recycling will help reducing creation of new inputs by mining or destroying our natural resources.

Table 4.1 Waste source and products

Sources of Waste	Products / Types
Residential	Newspapers, clothing, disposable tableware, food packaging, cans and bottles, food scraps, yard trimmings
Commercial	Corrugated boxes, food scraps, office papers, disposable tableware, paper napkins/tissue papers, yard trimmings
Institutional	Cafeteria and restroom trash, can wastes, office papers, classroom wastes, yard trimmings
Industrial	Corrugated boxes, plastic film, wood wastes, lunchroom wastes, office papers.

Solid Waste Reduction

The waste management hierarchy has source reduction as the first tier or basic function of the pyramid. This effectively focused on how to increase product durability, reusability and reparability.

The very basis of solid waste management hierarchy as per the first and foremost efforts of Environmental Protection Agency (US EPA, 1989), which had the agenda for action with concepts of integrated waste management; included source reduction. They managed practices with emphasis and approach tailor made for the requirement of societies, communities, municipalities, cities, businesses and organization's needs.

The components of waste management hierarchy include:

- Source Reduction (At source prevention of waste) – this includes reuse of products and at site or backyard composting practices
- Recycling, including off site composting
- Combustion with energy recovery
- Disposal through landfilling or combustion without energy recovery

Source reduction activities may include:

- Redesigning products or packaging to reduce the quantity of the materials used;
- Replacing lighter materials for heavier ones;
- Lengthening the life of products;
- Using packaging that reduces product damage or spoilage;
- Reducing the amount of products or packages used by businesses or consumers;
- Reusing products or packages; and
- Managing organic wastes such as food waste

Any sound waste management plan begins with prevention of waste in the first place. This is because today's generation generates wastes far beyond the levels ever recorded in the past. It is essential, therefore, to first understand why unmanageably huge waste is being generated by the current generation. The main reasons include

- Consumerism
- Higher disposable income Surplus production - pushing goods into new markets
- Packaging
- Changed attitude and lifestyle of the new generation
- Globalization

More and more non-degradable materials are being invented and used with frightening consequences. Consumption is being encouraged to meet mass production. Higher disposable income encourages a culture of throwing away goods without fully utilizing them. Development of logistics (especially e-retail) and consumption of packaged food require proper packaging material for safe and convenient transport. There is a vast geographical and social gap between producers and consumers, whereby the consumer cannot relate to the different aspects of production and the waste generated in the intermediate process.

In any case, it does not make sense to first produce waste and then struggle to find ways of handling it**.** For solving problems relating to waste in a realistic manner, we need to work initially to reduce consumption of items. Many people think that limiting consumption would impact the social standing of people and the country's development. Almost everyone is blinded by this mad rat race for becoming a developed nation. But the glaring fact is that an individual or a nation can hope for long-term growth, economically or otherwise, only by reducing consumption. In a country where consumption is limited by choice, the natural resources will be intact as the strength of the economy hinges on the availability of natural resources.

Case Study- Decentralized Waste Management

In July 2012, Alappuzha was facing a crisis. Known as the Venice of the East for its large network of canals, backwaters, lagoons and beaches, the city looked like a waste dump. Rotten garbage had piled up on roadsides, and canals and drains were clogged with bags of stinking waste. Swarms of mosquitoes and flies had invaded the city, spreading chikungunya and dengue.

Two-and-a-half-years later, Alappuzha had undergone a dramatic transformation. The dumping spots have disappeared. But where has all the waste gone? Is the city burying or burning waste under the cover of darkness? “No,” smiles Mercy Diana, chairperson of the Alappuzha municipality. “We’re on a clean city drive.”

Alappuzha, which has a population of 0.174 million and produces 58 tons of solid waste a day, is implementing a project called Nirmala Bhavanam Nirmala Nagaram (Clean Homes Clean City) since November 2012. The focus of the initiative is segregation and treatment of wet waste at the source. “About 75 per cent of the waste is biodegradable, and one-third of this comes from households,” points out Thomas Isaac, member of the Kerala Legislative Assembly from Alappuzha, who leads the initiative.

Suitable measures need to be taken before a material or product has becomes waste. This helps reduce the following in the waste:

(a) The quantity of waste, including through the **re-use** of products or the extension of the lifespan of products;

(b) The adverse impacts of the generated waste on the environment and human health;

(c) The content of harmful substances in materials and products.

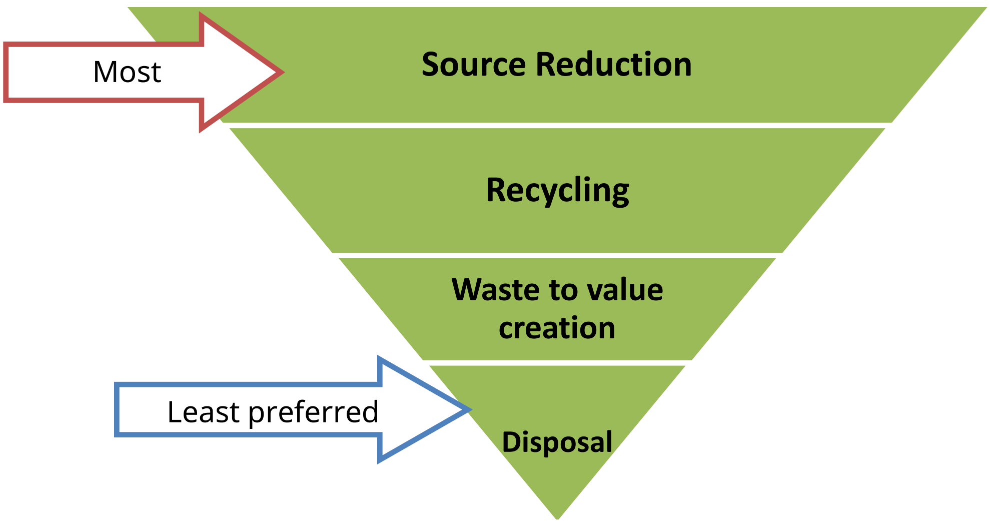


Fig 4.1 Waste Management Hierarchy

The above pyramid in the Fig4.1 begins with source reduction, because the best approach to managing solid waste is to avoid generating it in the first place. This will happen only by means of reducing the amount of waste one discards. It can be done by reusing the containers and products instead of throwing it away and increasing its use and avoiding its reach to landfill.

Film Analysis and discussion
What are the problems being discussed in the film?
What are the solutions being offered?
What are your key learnings from the film?
https://www.youtube.com/watch?v=asCJtKSma0E

Importance of Waste Reduction

Reduction and reuse of wastes are the most effective ways to protect environment and have cost savings. It has a positive impact on Economy. The economy benefits through source reduction because less waste means more efficient use of resources and manufacturing processes, thereby increasing competitiveness. Manufacturers are learning that reducing solid or hazardous waste in any manufacturing process usually lowers costs. The need to use resources more efficiently and produce less waste is being felt in the marketplace.

Source reduction will benefit manufacturers, retailers and consumers. It ensures the efficient use of resources resulting in sustainable development for long term. More the increase in efficiency lesser the cost. Hence, more companies are trying to implement waste reduction methods that help in protecting environment. It decreases pressure on the environment. Waste reduction at source is also referred as prevention.

Source reduction includes the following activities:

- Process modification
- Technological intervention
- Engineering methods
- Through old case history
- Reuse of products
- Behavioral change

ReciclaIsapor ® Campaign - Brazil

In 2015 Plastivida, an association of plastics makers in Brazil launched the "*ReciclaIsopor®*" campaign to educate Brazilians about the recyclability of foam polystyrene plastic and to encourage citizens to recycle foam at drop off locations. The campaign aimed to stimulate the "responsible consumption and proper disposal, based on the dissemination of knowledge about the recyclability of the material, as well as being a sustainability action that generates environmental, social, and economic benefits."

Recycling collection bins have been installed in various locations such as select grocery stores and the Sao PauloCity Hall to receive the material brought by the public, including foam packaging used to protect home appliances and consumer electronics. Instead of becoming waste or litter, the collected foam polystyrene is reprocessed and sold to companies that manufacture new products, such as moldings, baseboards, thermo acoustic tiles, flooring, slippers, puff filling material, flower boxes, and more. According to Plastivida, Brazil recycled 34.5 percent of the foam polystyrene consumed in 2012, which generated more than 1,400 jobs and R $85.6 million for 22 recycling companies. To increase recycling beyond that rate, Plastivida participates in events, lectures, workshops, and fairs and encourages media coverage of foam polystyrene recycling.

Benefits of source reduction include

1. Saving resources
2. Reducing toxicity of wastes (via use of alternatives /use of non-hazardous products, opting for eco-friendly products and recycled, refurbished products)
3. Reducing costs of management
4. Reduces GHGs emissions
5. Resource efficiency

Businesses/ Entities/Industries – They have an economic advantage by practicing source reduction. When businesses manufacture products with less packaging or packaging which is eco-friendly, their requirement for raw material for packaging is greatly reduced, which means larger profit margin and cost savings.

Consumers - Consumers can also share in the economic benefits of source reduction. Buying products in bulk, with less packaging, or items that are reusable (not single-use) frequently means a cost saving. What is good for the environment can be good for the wallet as well.

When does source reduction become vulnerable or exposed?

Source reduction becomes vulnerable or exposed if the practices are not brought into action as the government has little control over the amounts and kinds of consumer goods available in the market, nor over the packaging used for those products. Though packaging material classification is available based on its recyclability and degradability, packaging are as per the standards specified. But still at the manufacturing source level, a need for reduced and packaging based on recyclability is not available to the extent it is required and over packaging often results in increase in the volume of waste generation. Packaging plays an important role in terms of product integrity, promotion, safety and protection.

Basic Framework or Tool for Source Reduction Includes

- Capacity building and campaign for support of waste reduction and recycling – Public participation and stakeholder engagement
- Changing the very attitude of looking at waste

Possibilities for Source Reduction

- Study waste streams which includes quantitative and qualitative analysis and composition /characterization of wastes, recovery and recycling options, market availability
- Up keeping source separation, recovery, trading and incentives options and information dissemination for effective participation and implementation via networks like - forums for stakeholders.

- Facilitating small enterprises and public-private partnerships (PPP), availability of recycling centres.
- Promote residential and commercial composting (Onsite, backyard and offsite composting)
- Sell recyclables or license a private company /organization, PPP to sell the waste to create value
- Generating employment opportunities

In short, source reduction is best possible through the approach of product stewardship. Product stewardship can be defined as a concept-based method that addresses the environmental and economic impacts of a product through its life cycle – everything from design and manufacturing to packaging and distribution to end of life management. To further upgrade the benefits, the concept of EPR (Extended Producer Responsibility) which emphasize on sustainability, environment and cradle-to-cradle approach.

4.2 Waste Reduction Strategies – Economic Benefits

Waste reduction strategies include - Reduce, Reuse and Recycle

Reduce

- Purchase and use of durable, long-lasting products.
- Use products with less packaging, use packaging materials with high level of degradability and eco-friendly in nature.
- Reduce material usage in product manufacture.
- Increase useful life of a product through durability and reparability.
- Decrease toxicity.
- Material reuse.
- Reduce/more efficient consumer use of materials.
- Increase production efficiency resulting in less production waste

Examples for Waste Reduction

1. Flexible packaging waste prevention and management – concept by Smt. Almitra Patel, Member, Supreme Court Committee for Solid Waste Management includes: PE, PP, PS can all be recycled to gatta (lumps), daana (pellets) and products: Pipe, Hard plastic articles, some film tubing. Soiled mixed-films (carry bags, road litter) can be usefully shredded to improve tar roads: over 5000 km since 2004.
2. Shredded Plastic Film used for doubling road self-Life: Mixed plastic film is shredded to 2-4mm size and sprinkled onto heated mixed-stone aggregate. 30-second mixing time allows plastics to soften and uniformly coat hot stones like a baked-on primer. Molten asphalt added to this adheres well, doubles road life, reduces potholes, and improves wet strength.
3. Using only compatible thermoplastic layers.
4. Eliminating nylon and polyester layers.
5. Working with plastics recyclers

6. For toffee wrappers, mini–sachets, pesticide packaging, using compostable multifilm of BIS/ ISO 17088 / ASTM D6400-99 / EN 13432
7. Use Compostable bio-plastic barrier-films in sanitary napkins & disposable diapers

Reuse

Reuse products by repairing them, giving away used items for reuse by needy groups, NGOs, marginalized and vulnerable communities or selling them. Reusing products, is even better than recycling because the product does not need to be reprocessed before it can be used again. It extends its reach to landfill (avoiding waste to reach landfill).

Ways to Reuse

- Refill bottles.
- Donate unused products, containers, clothes and other day to day things.
- Reuse boxes.
- Turn empty jars into containers for storage.
- Reuse program – Exhibition, capacity building and awareness initiative

Recycle

Recycling converts materials that would otherwise become waste into valuable resources for usage in some other product as input raw material post processing. Materials like glass, metal, plastics and paper are collected, separated and sent to facilities that can re-process them into new materials or products, recovered to be converted into energy.

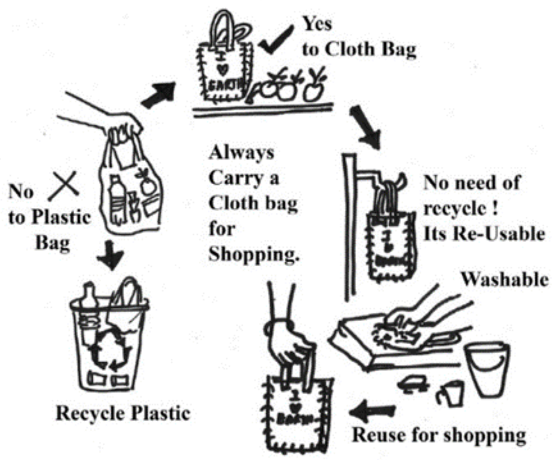


Fig4.2 Re-cycle and reuse of items

Design for Environment (DfE) and Design for Recycling (DfR) - Circular Economy

Circular economy is a model for environmentally sustainable economy, resilient in the face of resource insecurity and ecological crisis and aims for extended use of products and services. It aims for circularity in design and starting from the stage of production, consumption, return, recovery, recycle and transform.

✓Redesign through innovation- reuse and recycle with transition strategies towards efficient and optimized plastic packaging can be win –win proposition.
✓Replace single-use plastic bags by reusable alternatives.
✓Scale-up reusable packaging in a business-to-business and consumers to business approach. Provide recycling centers hub for consumers.
✓Drop box facility for consumers to drop their plastics, e-waste and other wastes of value that can be brought back into value chain.
✓Plastic packaging, which often subjected to leakage into the environment, generates negative externalities, degradation of natural systems and greenhouse gas emissions that have been valued conservatively by UNEP at USD 40 billion.

What should Design for Environment (DfE) and Design for Recycling (DfR) provide?

There has to be an increase in the demand for recycled plastics through voluntary commitments and or policy measures to supporting recycling. Packaging to be strategically designed for the product in order to optimize overall environmental performance

- ✓ Should be made from responsibly sourced materials
- ✓ Should be designed to be effective and safe throughout its life cycle
- ✓ Should meet market norms for performance and cost
- ✓ Should meet consumer expectations
- ✓ Should be recycled or recovered efficiently after use

Certification of circular economy products can be used to communicate the sustainability of products and services, and the reparability and recyclability of products. This would help consumers in their everyday choices. Further consideration is required on the compliance of circular economy with sustainable development and on the role of certification.

Regardless of the measures policy and decision makers plan and implement in the form of providing incentives, collecting wastes taxes, change in the way of deploying to waste collection, recycling, and processing of waste; we will never achieve truly mission of clean cities and Swachha Bharat unless there is a fundamental shift in public mindsets and behaviour towards producing less waste and also alternatives not provided for the citizens for use.

Using Products as Services

Vodafone's Red Hot

You can rent the latest phone for a year and keep on exchanging it for a newer version. Assuming Vodafone is engaged in collecting the old phone, not only does this act as material collection and pooling but, from a business standpoint, it also creates deeper customer relationships.

Tata Motors Assured

It is more than a second-hand car dealership. Cars are handpicked and refurbished in Tata workshops and then undergo a certification process. Customers are even offered financing options and warranty.

BMW's Remanufactured Parts

For BMW, product transformation can mean a 50% cost saving for customers buying remanufactured parts as compared to new ones. You get exactly the same quality specifications as a new BMW part subject to the same 24-month warranty.

Innovation in Recycling

Innovation in recycling technology is rapidly evolving and enabling the production of high-quality products with fantastic sustainability performance.

Starbucks's Recycling of Waste Coffee Grounds

Starbuck aims to turn thousands of tons of its waste coffee grounds and food into everyday products by using bacteria to generate succinic acid, which can then be used in a range of products from detergents to bio-plastics and medicines.

Extended Producer Responsibility (**EPR**)

Extended producer responsibility (EPR) is a strategy designed to promote the integration of environmental costs associated with goods throughout their life cycles into the market price of the products (OECD, 2001). It focuses on the end-of-use treatment of consumer products and has the primary aim to increase the amount and degree of product recovery and to minimize the environmental impact of waste materials.

The EPR conceptualization and thought process has the following key considerations:

- Product design shift
- Environmentally sound waste management
- Financial responsibility
- Physical responsibility
- Product responsibility

Extended producer's responsibility (EPR) is considered as main feature of E-waste (Management and Handling), wherein the producer of electrical and electronic equipment is given the responsibility of managing such equipment after its 'end of life', thus the producer becomes responsible for their products once the consumer discards them. Under this EPR, producer is also entrusted with the responsibility to finance and organize a system to meet the costs involved in complying with EPR (Johnson, etal, 2014).

Life Cycle Assessment

Life cycle thinking means accounting for economic, environmental and social impacts across all stages of a product or process life cycle. This perspective informs the design team of the product's life cycle impacts across a range of sustainability issues (i.e. greenhouse gas emissions, jobs created, daily average life years, etc.).

Life cycle thinking is based on and requires using some form of Life Cycle Assessment (LCA), such as:

- Environmental LCA
- Social LCA
- Life cycle cost analysis or total cost of ownership
- Streamlined LCA

The typical life cycle stages considered when evaluating the impacts of a product or service are listed below. The number of stages to include in your life cycle thinking depends on the product or process. Transportation between all stages should be included as well:

- Raw material extraction
- Material processing
- Manufacturing
- Use
- End-of-Life

How to Start a Waste Reduction Program Guideline

The best way to reduce the amount of waste produced is to look at your trash as you are throwing it out and ask yourself these questions:

- What do you throw away?
- What materials take up the most space in the trash bag?
- Can any items be reused, repaired, or donated?
- Can you reduce the number of disposable items used?
- Can you substitute products with ones that can be reused or that have recyclable packaging?

Learn what is accepted in your municipal recycling program. Then list the items in your trash that are not recyclable. The next time you go shopping, try to find recyclable alternatives to those items in your trash. If you have too many left over products, consider giving them to someone else or next time buy fewer of them.

Waste Reduction Ideas

- Use china and silverware, instead of disposal paper plates and plastic flatware.
- Use both sides of a piece of paper before recycling it.
- Pass on already read books, magazines, and newspapers to friends or co-workers, schools, libraries, nursing homes, churches, or other charitable organizations.
- Buy durable, well-made and/or repairable products.
- Use plug-in appliances, instead of battery operated ones. Single-use or even rechargeable batteries can end up in the landfill.
- Use a sponge or dishcloth instead of a paper towel to clean up a spill
- Buy the largest-size food packages that you can use without spoilage

- Avoid using plastic bags for produce purchases. Simply place produce loose in your cart or basket
- Use re-useable bags to transport items from the store to home (i.e. canvas bags)
- Consider contacting the manufacturer if your favorite brands have excessive packaging and express your concern about reducing waste
- Borrow, rent or share items that are used infrequently instead of buying them.
- Reduce the amount of mail you receive or send. Don't sign up for information you really do not want.

How to Start a Recycling Programme?

Every individual, society, community, organizations, institutions, business entities generate a large volume of waste every year. What can be done about it? While participating in local recycling programmes is considered as an excellent way to divert waste from the disposal process, the most environmentally and economically sound solution is to create less waste in the first place and secondly opt for recycling. A recycling programme planning includes the following planning steps or stages as represented in the Fig

Fig 4.3 Planning Steps or Stages in Starting a Recycling Programme

4.3 Source Reduction vs Waste Reduction

Source reduction enables the activity of recycling. Economic benefits drive actions in the real world and for an effective recycling program, the benefits of recycling need to be focused for example growth of employment opportunities in recycling industry. Recycled products are affordable/ and provide significant cost savings.

There are different types of recycled products available in the market and with due changes in technology, today's recycled products can meet the highest quality standards based on a viable high demand. Recycled products are being used in the retail sector and also found in major retail stores, supermarkets, garden centers, local shops, catalogs and on the Internet. Many recycled products cost the same or less than comparable products made with virgin feedstock. By purchasing recycled products, consumers can help create long-term stable markets for the recyclable materials

As per the data status by Rajiv Agarwal, Director, Toxic Links[1],

- Plastics: 8.5 million tons per annum (consumption), 6 million tons per annum is waste generation. Number of authorized recyclers - 3500. Around 70% of plastic waste recycled in the informal sector

- Lead Acid battery. 161.7 billion INR in 2012. 4.43 million tons of waste generation. Authorized recyclers – around 450. -In Delhi NCR 70 unorganized lead acid smelters, employing approx. 840 workers.

- Electronics industry – around $100 billion, Consumer electronics industry $9.7 billion in 2014, set to hit $20.6 bn by 2020. E-waste generation- 1.8 million tons. 138 authorized recyclers in India. About 95 % of the e-waste is being handled by the informal sector

  The key economic benefits of waste reduction include:
  - Avoids expensive disposal costs
  - Lessens the need for costly alternative treatment of waste
  - Saves on raw material and manufacturing costs

Cost Savings

Say for example a business must make a profit from waste management: If waste management costs are charged directly to the process that generates them, we shall get a true assessment of that process's profit/loss status.

[1]https://www.oecd.org/environment/waste/Session_1-EPR-Toxics-Link1-Ravi_Agarwal.pdf

Case Study: Suryapet Municipal Administration in Telangana

Suryapet municipal administration in Telangana is adopting the best practices in solid waste management in the country where they do not mix wet and dry wastes said Member, Supreme Court Committee for Solid Waste Management, Almitra H. Patel, She cited the example: Suryapet, Telangan is the only Zero- Dustbin and Zero Waste town to get ISO 14000 in 2006. Secret of success: Only Administrative will with no excuses. "TOTAL COMMITMENT" to Waste Management by both Commissioner and Councillors. Achieved by CMR Khadar Saheb in 18 months from 2002 only with own labour and no state or central funding, NO user charges to citizens, NO NGO support.

Source: almitrapatel.com

Operation on a Daily Basis

Operations in waste reduction are based starting from individual to business standpoint and strategies differ based on different waste characteristics. Operations, in this context, include all activities directly involved with making the product or providing the service and its usage in daily lives and how through optimized use, recovery and reuse effective waste reduction can be implemented across all the hierarchies.

The operational most wastes functionalities in waste reduction include:

- Processing
- Purchasing
- Receiving
- Delivery
- Inventory
- Personnel

Processing

It includes evaluating processing areas at the time of waste audit, by audit team and considers the following measures:

- Source reduction
- Scheduling procedures
- Waste segregation
- Maintenance

Purchasing

The way purchasing is done should include awareness, education and sound knowledge about what products to purchase and what packaged products are purchased.

- **Unified purchasing:** It includes routing all the purchases through one department/shop/grocery store having one uniform flexible waste reduction policy.
- **Pre-purchase plan assessment:** Buying nontoxic (or the least toxic) material. Plan to use compactable and recyclable products
- **Minimize types of raw materials:** Reducing the number of raw materials, feedstock used as much as possible in the product line and promote recyclability in long term upon recovery from products after end use.
- **Inventory regulator:** Purchasing or buying as per requirement as over-purchasing holds the capital and induces losses if not disposed, stored properly.
- **Material Safety Data Sheet information (MSDSI):** Material Safety Data Sheets contain manufacturer's information on a material's chemical, physical, and toxicological properties as well as proper handling and storage procedures.

Receiving

Proper receiving procedures promotes worker safety and minimize waste generating problems such as broken or leaking containers, damaged merchandise, and spills from tank and unloading.

A few good practices to consider are the following: 1. Designated point to receive 2. Training to employees 3.Knowing your supplier 4.Inspecting the products, materials at the time of receiving.

Delivery

Well planned out delivery procedures to protect organizations, institutions, communities and societies and reducing waste. They are complementary to procedures for receiving materials.

Inventory

The following points have to be taken care of under inventory:

1. Materials Inventory: Excess inventory or reactive, toxic, or ignitable materials increases the chances of spills, exposure and worker ill health
2. Size of the container: Purchase materials in a container sized to the amount you are going to use.
3. Storage area: Should be clean, safe and efficient with ease of clean up.
4. Shelf life should be monitored and FIFO or LIFO standards implemented.
5. Product and process changes: When a product or its process is changed, raw materials, which are already in inventory, are sometimes no longer needed. Suppliers need to from the point of cost optimization should include liability in mismanagement, incase materials return back.

Personnel

Progressive personnel responsibilities and commitments maximized waste reduction. Also in case of industry, it minimizes accidents and losses, provides a productive workforce

Some Innovative examples being undertaken for waste reduction:

- Paper Reduction through e-Government: The implementation of technology-based document management, electronic filing, and other online systems to replace the use of paper;

- Policy Frameworks for Sustainable Operations: Innovative municipal policies for resource conservation, holistic decision making, and protecting public and environmental health;
- Disposable Bag Policies: Examples of store-level fees on the use of disposable carry bags;
- Environmentally Preferable Purchasing Policies:

• Biodiesel Use in Fleet Vehicles: The use of recycled vegetable oil to power fleet vehicles

4.4 Present Scenario of Solid Waste Management in ULB and Rural Areas and Best West Disposal Practices

Rural Areas

India's 6 lakh villages and small hamlets are cleaner than urban areas and are also the easiest to keep clean. They have 67% of India's population, so Swachha Grams will lead to a Swachha Bharat. The rural areas have implemented waste management partially and slowly and steadily improving their status under Swaccha Grams.

Pit Composting: Every home has animals to which leftover food waste can be given. What is wasted by them is used even today to make organic manure for farms and fields. It is usually stored in a pit until it is needed before the next planting season. Because it is mixed with cow dung and is added to the pit in small daily quantities, the waste does not smell. These pits should be only in private plots or farms, not in public spaces or roadsides, where passers- by may throw in plastics or other non-biodegradable wastes.

Eateries: Village anganwadis and schools serving mid-day meals, roadside eateries and shops must arrange to add only their unmixed food wastes to a nearby compost-pit by arrangement. They must be required by panchayat resolution to use only washable plates, or leaf-plates and cups which can be added to compost-pits. **They should not be allowed to use disposable paper or plastic plates.** If they do discard plastic ice-cream cups etc these should be washed and given as recyclable waste at drop-off points or kept until weekly doorstep collection is done. NO WASTE SHOULD BE THROWN BEHIND SHOPS OR ALONG THE ROAD and offenders should be penalized.

Packaging waste: Shops should been courage to use paper or leaf wrapping and not plastic. However nowadays many pre-packed foods come in plastic which needs to be well-managed. Panchayats should provide a drop-off point for all such non-biodegradables.

Weekly Pickup service: If panchayats choose to provide a weekly (not daily) doorstep pickup of plastics and other recyclables, it should preferable be done not in a wheel barrow where everything will get mixed, but in a local handcart with 4-6 plastic bins of 60-89 litres and lots of hooks to hang different sacks on the sides (used cement or grain sacks. They can also get a double handled pushcart with jumbo sacks as shown in Annexure B which is ideal for doorstep collection in the smallest to the largest cities and metros. Waste must first go into a sorting basin, then into 'wet' bins.

Many large sacks can be hung open for separately filling with paper, plastic and 'other' non-food waste, so that sorting gets done during collection itself for added recycling value and does not require an additional space for sorting. Such push-carts should also have a 20-litre shallow basin in which waste is received at the doorstep and non-biodegradables picked out of wet waste before adding it into the bins.

Temporary Storage: Only a small room or covered space is needed for temporary storage of collected sacks. Panchayats need to tie up with a waste-buyer or have monthly auctions to dispose of the collected material, even at nominal cost.

Most of the unwanted non-recyclable waste in villages is snack- food packs or tiny pouches and sachets. These are very bulky when loose and costly to transport away. So, these should be foot-compacted in large sacks (used for maize, sugar etc) or foot- compacted in a wooden baling crate and then tied tightly with plastic twine in bundles which are economical to transport.

Residual Wastes may also be there in very small quantities, about 5- 10% of total waste of all kinds. The District Collector should innovate some locally suitable solution for yearly removal of residual wastes to keep the villages clean.

Street Sweeping is traditionally done by occupants of street-facing buildings who sweep and keep clean their half of the road in front of their properties, including keeping drains clean and free-flowing to minimize mosquitoes and malaria, flies and diarrhea. This good Mera AanganSaaf policy needs to be encouraged everywhere with gram sabha support. Then no separate sweeping staff are needed. Heaps of dust can be used for pothole filling or road-widening at the nearest point.

Burning Waste on Roadsides is Banned by Law.

Sub-Post offices and banks must not burn their waste papers. These can be shredded or packed in sacks and sent to their head offices if not taken to the panchayat drop-off point for auctioning. State Postmasters- General and Zonal Bank managers should enforce this.

Bus Stands should have litter-bins and throwing waste on the ground by both locals and visitors should be discouraged. Litter-bins are not preferred in many areas for fear of fires from discarded cigarettes and antisocial elements. Disallow sale of peanuts in shells and green gram on stalk etc.

Monthly Cleaning Drive should be arranged by Panchayats to clear away building debris and unused construction material on the roadside like leftover stones and bricks or blocks and use them for road improvement or take them to a planned disposal point. This should not be beside a lake or river or low-lying depression as these spaces are needed for ground-water recharge.

Festival Waste Management should be planned by Panchayats or gram sabhas in advance and provided for, to prevent waste from annual temple events and national festivals or crackers from lying around for long and spoiling the cleanliness of the village. Keep a 'nirmalya-kalash' for collecting all flower-offerings free of plastics.

Class 1 Cities with 1 To 10 Lakh Population – Semi Urban

These 415 million-plus cities with a total population of 104 million in 2011 census accounted for 28% of our total urban population. All of the above guidelines are useful for them also.

They also have their own very detailed guidelines since March 1999, in the form of a Report on Solid Waste Management in Class 1 Cities of India by an Expert Committee appointed by the hon. Supreme Court. This needs to be translated into regional languages in every State and Union Territory. Its recommendations and technical aspects need to be translated and distributed down the line to the supervisors, /mukadams / maistries, each of whom supervise about 20 safaikarmacharies or ground-level workers. It's also serve are guidelines for top-level city managers and councillors.

However, all Class 1 cities must remember that they are made up of Wards which each have the population of 25-50,000 like the Small Towns above. So decentralized waste management as described for these Small Towns is also relevant even for the largest cities.

Mandatory Resolutions

Make it mandatory for citizens to keep wet and dry waste unmixed. After three warnings, either refuse to collect mixed waste or charge a daily fee for sorting it at their doorstep.

Make it mandatory for ULBs to ensure Separate Collection and Separate Transport of Wet and Dry Wastes. This is a prerequisite for citizen cooperation and waste minimization. See Contract Management in Section 6.6 below in case any outsourcing is done in the largest cities.

Daily Collection of Wet Waste (food, fruit flowers) is necessary, even on holidays.

Weekly Collection of Dry Waste may need a municipal resolution. The sale proceeds of dry recyclables should go only to the primary waste-collection team to incentivize unmixed collection and thereby waste reduction.

Unwanted unsalable non-compostable should have a separate destination from wet waste. Baling is necessary to transport them economically.

Ban PVC Banners, Hoardings and Vinyl as they are unrecyclable.

'Plastic Roads'

These polymer-modified bitumen roads should be mandatory and specified in municipal road tenders**.** All cities must use unrecyclable plastics (like snack food sachets and thermocole) either as cement-kiln fuel or in P2F plants where available (see 1.46) or in hot-mix asphalt plants so as to consume all remaining non-recyclables in 'Plastic Roads' within the city. This will give 2-3 times the normal life of bitumen roads. It is approved by Indian Roads Congress. Refer to CPCB's guidelines PROBES/101/2005-06 on how to use waste plastics and PROBES/122/2008-09 for data on improved tar road quality. No non-recyclable plastics should end up in landfills.

Street Food Waste Management

Medium and large cities have numerous pushcart vendors moving along streets as mobile shops for the great convenience of residents. But they must be required to have a dustbin as well on the lower shelf of their handcarts. Ideally, each pushcart should go to its night destination along with its waste and give that to the doorstep pushcart collectors in the morning. Otherwise, each Ward will have to individually decide when and where these hand-cart emptied wastes must be unloaded at the end of the working day and how they will be removed for processing and disposal.

Market Waste Management

The door-to-door pickup becomes here a stall-to-stall pickup service, every hour or two-hourly or 3-4 times a day as needed, by the existing market-cleaning staff, preferably paid by stall-owners. Every vegetable-fruit-flower stall must keep a small basket within their stall space for wet waste only. A pushcart continuously moves up and down along the rows of shops so that the baskets can be quickly emptied into it without overflowing.

The pushcart unloads its wet waste collection directly into a waiting trailer or tractor or lorry to be taken away at the end of day. If this vehicle fills up within 3-4 hours, it can go straight to the city's cattle-pound as feed, or to farmers. Otherwise it needs decentralized bio methanation or stack composting or goes directly to a centralized site for wind-row stabilization.

The same stall-to-stall frequent pickup service for emptying waste-containers is a must in fish-markets so that nothing is thrown on the floor or shop platform. It helps to spray on odor-control or composting bio cultures at the market itself so that transport through the streets is odour-free and composting begins before the waste can rot. The cost should be borne by all the stall-owners on polluter-pay basis.

Market stalls also have a lot of dry waste like the newspapers wrapped around papayas, or plastic wastes. These must be collected in separate jumbo bags hung behind or under the stalls, and a waste-picker or kabadi service arranged to collect or buy it at the end of day.

Wholesale Market Packaging Wastes

Packing straw around fruits etc coming into wholesale markets MUST NOT BE ALLOWED TO BE UNLOADED ON THE ROAD. The trucks must take all this out of the crowded market area and unload it at a nearby waiting truck before they proceed to another transport job. This straw can be taken to a cattle pound or goshala or any cattle-owner who asks for it. Or it can be used as cover for windrows. It is not advisable to add it into biogas units.

Wholesalers sell the produce in cartons or baskets to the retailers having stalls or pushcarts. There must be a take-back policy for such packaging**.** For every box or basket the wholesaler gives a retailer, he must take back a box or basket and load all these empty returns into any just-unloaded truck leaving the market, for sale or disposal outside the markets. Interested buyers may be allowed to come and collect such packaging waste at end of day, or waste- pickers with identity cards may take it away. Both should pay some nominal cost or they will be irregular and not value what they can collect for free.

Use secondary transport garbage vehicles in the early mornings for a wholesale-market-waste trip before they are needed later in the day for pickup of pushcart bins from micro-planned doorstep-collection routes.

Market Cleaning Contractors

In many towns and cities, contractors bid in auctions and pay fixed fees to the city in exchange for the right to charge a daily fee for temporary stalls or spaces, especially in farmer markets along roadsides in the evenings or at annual fairs and exhibitions. 'No-waste-on-road at any time'must be a compulsory clause in such contracts.

Market Waste to Cattle Pounds and farmers

Unmixed market waste is useful feed for large and small animals if delivered within 12 hours and becomes useful manure in a day. It is also wonderful for composting in farmers' fields. Farmers should be encouraged and helped to bid for and take away the market waste to their fields on a regular or seasonal basis as organic fertiliser.

Co-Digestion with Sewage Sludge

Most large sewage treatment plants (STPs) have been designed with big digesters to produce biogas from the sewage sludge, as drying beds take too much space and time. Surat has a very successful gas-generation unit in one STP which runs on the power it generates. Most of these units are no longer functional, or produce very little biogas.

In the West, STPs try to be 'carbon-neutral' by generating on-site their own power requirement for operations. To increase gas yield, they purchase and add to the STP some Fat, Oil or Grease (F O G). This is so successful that they earn income from exporting surplus power to the grid. In cities wishing to manage their unmixed wet waste in a decentralized way, shredding and adding it to sewage sludge in existing STP bio digesters is a very cost-effective option and will also increase gas yield. Non-veg waste free of feathers and and fish-scales can also go into biogas digesters.

Hotel and Eatery Waste Management

Hotels, party halls and eateries need to sort their waste into three categories. Kitchen and food waste (before and after cooking) is good biodegradable wet waste. It is best fed into a biogas unit onsite to produce cooking-gas for their own kitchen. Adding kitchen-vessel and plate wash-water into the biogas unit helps produce more gas. Or it can be sent to piggeries (if tea leaves and coffee grounds and lemon peels are kept out of it). Or it can be collected by a central biogas-bottling plant. Clean dry recyclable waste (packaging, rinsed PET bottles and Tetrapaksetc) can be sold to waste-buyers or given away to waste-pickers.

Soiled recyclables like disposable plastic plates and paper tea-cups are a problem and must not be mixed with the clean dry recyclables. Disposables must be avoided and washable items used instead. Some items like soiled ice- cream and yogurt cups and plastic spoons etc can be thrown directly into a mesh basket immersed in water with a little detergent. The mesh basket can be lifted up for drip-drying so that the items become saleable and recyclable like other dry waste. Plastic film table-cloths must be banned by the city, as these are often rolled up along with disposables and leftover food and cause cattle deaths when eaten.

Million Plus Cities, Population Over 10 Lakh

In 2011 these 53 cities, including 3 Mega cities over 10 million (Greater Mumbai, Delhi, Kolkata) had a combined population of 161 million or 42% of our total urban population. All million-plus cities are growing fast and so need long-term planning and a city-specific Waste Management Plan. All of the suggestions given above and in the Supreme Court Committee Report can form part of the customized plan.

State Waste Management Authority

An autonomous body like a Water Supply Board or ESCOM should be created to provide vision, a long-term Waste Management Plan and continuity of policy, strategies and decisions. This is necessary to insulate city management practices from the changeable decisions of new Commissioners, new mayors and elected councillors (many of whom have a conflict of interest with waste- management contracts) and changing political majorities which may or may not match the ruling parties at State or Centre.

Consume Stabilized Waste within the City

The main difference between large cities below and above 1 million is that in million-plus and mega-cities, farmlands are much farther away from city limits. These are also sprawling cities where decentralized Ward-wise or at least Zone- wise waste management is very necessary for both cleanliness and cost- effectiveness and transport savings and decongestion of traffic.

Here, the stabilized wet waste needs to be consumed within the city's parks, roadside plantings, road dividers and traffic islands for use as organic manure. The surplus may need to be given away at nominal cost, or delivered at the city's cost to farms or to compost plants outside the city where the stabilized waste can be sieved, enriched and bagged for sale as compost meeting FCO standards.

WASTE COLLECTION IN SLUMS

Slums are 'authorized' or 'unauthorized' unplanned areas of our largest cities where there are poor or no civic services like power, water supply, drainage or sewage management and waste collection. In the largest cities, only pedestrian movement is possible within some slums and even bicycles cannot enter.

Cities are only as clean as their dirtiest areas, so city managers must give their poorest the priority hat Gandhiji always kept in mind. Only political and administrative will is needed to keep slums clean.

Waste collection is easiest in slums, because slum dwellers are always the most neglected sector for waste collection. They desire and understand the need for a clean environment and the costs of ill health, so they are the most willing to cooperate in improved waste management efforts. Slum dwellers are also the most willing to pay for regular and dependable good waste management despite lower incomes. But no user fees are needed if on-site composting can save transport costs for the city.

There are several easy proven methods for slum wet waste collection and treatment:

- Shared bins for on-site composting
- Shared biogas units to produce cooking gas for community kitchens 3, Door-to-door collection in handcarts
- A lorry at the slum entrance
- Community bio-bins
- Exchangeable bins at the slum entrance
- Take-away bins in narrow lanes

The slum-dwellers need to be consulted on which system they would prefer.

Shared Bins for on-site composting are large barrels raised slightly off the ground on bricks, with a perforated bottom and sides, into which 4-5 self- selected families deposit their unmixed wet waste daily. These thin layers are self-aerating and do not smell. The drum has a small door near the bottom to remove the fully matured compost. NGOs regularly purchase this compost from them to motivate careful use of drums and addition of plastics-free waste.

Shared biogas units receiving wet waste from a group of families can provide cooking gas to one or more of them or to a community kitchen where residents bring their own vessels and food ingredients for cooking. Gas production is very much more if the biogas unit of a community toilet is used for both sewage treatment and wet waste treatment. Prior social acceptability is necessary but possible.

If lanes are wide enough, the usual **pushcarts** may be used for doorstep collection of wet waste which is brought out of the slum.

It is suggested that where lanes are too narrow, residents walk to slum entrance and dump their waste just outside the slum. It takes a half-hour to clear this heap. Instead, an **empty truck can wait at that spot punctually for a half-hour** while the cleaner walks through the slum whistling to invite residents to come deposit their waste directly into the waiting truck and NOT on the road at any time.

Community bio-bins can be placed at the same slum entrance or earlier dump for wet waste to be deposited into a biobin (one pair for 40 kg per day). Residents can be paid for the compost thus produced.

In smaller unrecognized clusters, or where workers leave before dawn, if one family or shop near the entrance will take the responsibility for it, a bin is kept at the former 'black spot' location to receive only wet waste: a 50 liter's bin for every 50 houses. At the transporter's convenient time, the **filled bin is taken away and replaced by an empty one** for next morning, which the in-charge resident or shop keeps safely indoors until it is put out early the next morning.

In a huge slum in Mumbai, the slum association appointed youths for cleaning work and **take-away bins**, before they go to college or jobs, paid for by resident contributions of Rs 5-10 per family per month. Road-facing shops pay more. A mass clean-up drive is a must, immediately before the new system is started

7-8am: narrow open drains beside internal paths are swept clean.

8 am: 50-litre bins given by the city are **placed at internal path crossings**, one per 25 homes or so.

8-10 am: waste is carried from each home to nearest bin at residents' convenient time, often by tiny tots.

10-11 am: All bins are removed and unloaded directly into a waiting truck outside the slum. Daily punctuality by the city truck is vital!!

11-11:30 am: Bins are stacked till next day in a protected open space (timber- yard etc). Youths leave for college or jobs.

Manpower Management

It is very important to keep permanent workers contented by prompt payment in exchange for work performance up to pre-set norms and targets. Avoid 'group work' and instead allocate 'pin-point beats' such as cleaning a specific assigned half-kilometer of roadside drain or stretch of storm-drain to one specific person. This improves work accountability.

Discontinue unproductive work like sprinkling lime powder as 'VIP Rangoli" which requires time to both spread on one day and remove the next day. Instead, paint permanent white lines along road edges which will show equally well whether the road has been properly swept or not.

Strictly control the tendency of councilors to demand he free and unauthorized services of cleanliness workers as their gardeners, car cleaners, house help etc. Also strictly discourage the tendency of councilors to demand attendance of supervisory staff and lower-level officers at their residences in the mornings. These persons are needed all morning in the field for effective supervision. They should report to councilors' homes not more than once a week, only in the afternoons, or to attend monthly Ward Committee meetings.

Outsourcing Waste Management Services

This is recommended only for the largest cities, especially in unserved areas where the cities have expanded by absorbing surrounding villages without earlier waste-collection services.

Never outsource more than 50% of total waste-collection operations to one or more service providers, to keep a balance between permanent employees' labour unions and private companies which badly exploit cities where they control the full operations.

Contract Management

When cleaning work is outsourced to private parties, the contract should never be given only on a per-ton-payment basis or per-trip distance-based basis. This encourages a countrywide malpractice of resisting waste minimization and falsifying bills for trips made. Per-ton payment also encourages the mixing of heavy debris into mixed waste or even wet waste. So payment should be based on a maximum allowed weight per vehicle volume, as one cubic meter of wet waste should weigh only about half a ton. (density 0.5 to 0.6 kg per cubic meter).

Contracts can preferably be given on a per-capita or per-household basis depending on the population of the area to be covered. This will encourage contractors to find ways to minimize the waste they have to transport over long distances. Instead they will make the same money as before by unloading dry waste within the ward and preferring decentralized waste-management points like bio-methanation units or stack composting.

It is easy to calculate say the per-household rate by dividing the cost of an earlier tender amount by the number of census households in the given area.

The city can then fix the same per-household rate as the base price (or with slight escalation) and invite tenderers to bid at or below that indicated per- household rate to win contracts. Tender renewals or fresh tenders become very easy by just adjusting for the number of households added in the meantime.

There should be minimum insistence on expensive vehicles like compactors. Contractors should be urged to adopt micro-pocket push-cart collection which enables doorstep sorting and sub-sorting of wastes. They should be left free to opt for the most cost-effective and convenient secondary-transport methods they choose, provided there are no citizen complaints of poor service and no spillage of waste or dripping of leach ate on the roads they pass through.

Recognizing the Informal Sector

For decades, waste-pickers, 'kabadiwalas' and scrap buyers have provided free services to cities in minimizing their waste quantities by collection and recycling. So far this has been done in the most inhuman conditions, and with police harassment and denial of access to waste. With doorstep collection of unmixed waste, the doorstep collectors themselves should be allowed to sell their sorted recyclables and retain the earnings from it. Waste-pickers may also be permitted to voluntarily follow the 2-man pushcart collection teams if it suits both parties.

Some cities are preferentially awarding some percentage of their outsourced contracts to Self-Help Groups of waste-pickers or giving them Identity Cards to avoid police harassment. This has greatly benefited cities who are sincere about their upliftment by prompt payment for services rendered.

No Tipping Fee, Only Support Price Payments

If outsourcing is done for processing and disposal activities, payment should never be on he basis of waste tonnage or volume received at the site. This encourages acceptance of waste without doing any processing. This leads to enormous concentrated pollution, local unrest, loss of a potential waste- processing site and resistance to opening of new sites. Instead, payment should only be an output-based support price, based on quantity of compost or biogas or briquettes or P2F fuel produced. Only this can ensure that contractors will try to maximize actual processing into such products.

Cleanup of Old Open Dumps by 'Bio-Mining'

Until 1960s, all urban households threw out only kitchen waste and some paper and leaves. Farmers eagerly emptied urban dustbins to take the pure wet waste in them back to their farms for composting. Two things changed in the sixties: plastic waste began to be thrown out along with kitchen waste, making it unusable for farmers. Secondly, massive subsidies on urea killed the composting habit.

So mixed waste began to be dumped in the open outside towns and along highways, breeding huge numbers of aggressive stray dogs as well as flies, mosquitoes, rats and other pests. The MSW Rules 2000, forty years later, tried to correct this by requiring hygienic eco friendly composting in special sites. All Indian villages, towns and cities today, from the smallest to the largest, have open dumps where waste has been deposited at least from the sixties. As building activity increased, debris also began to be collected and dumped along with mixed waste. Some cities wrongly cover the open dumps of mixed waste with layers of debris or soil, making everything even more unusable.

These old dumps need to be cleared for many reasons: to reduce the methane and leachate still coming out of them for years to come, to remove such dumps as towns and cities grow, and to clear these spaces to ground level for re-use as waste-processing sites. We have many successful examples of clearing all existing dumps of untreated garbage by 'Biomining', which can remove and usefully re-use upto 90% of the old dump, without moving it to another place. Steps are:

a. Sprinkle the surface with a composting bioculture solution or a dilute solution of 5% fresh cowdung in water. This will control smell and speed up decomposition.

b. Loosen the surface to a depth of 200 to 400 cm with a tractor-mounted cultivator (harrow).

c. Hire waste pickers or labour to manually pick out bulky waste like coconut shells, banana stems, tyres and rocks. Store in separate heaps for sale or use.

d. With a JCB or earthmover, form the loosened top material into long heaps (wind-rows) 2m to 2.5 meters high.

e. Turn these windrow heaps once a week for 4 weeks as is done for fresh waste. The volume will reduce by 40% and the waste will be fully stabilized, meaning that there will be no smell or leach ate formation and the material will be dry enough for sieving.

f. Screen the stabilized waste in a rotary screen or gravity screens of different size openings, preferably 100 mm, 35mm and 8mm. A fan can blow out the plastic fraction for use by recyclers.

g. Use the different fractions for different purposes. The finest fraction will be organic matter plus fine soil, called 'bio-earth', which can be used as soil improver, especially for restoring alkaline or saline soils to fertility. The next coarser fraction will be gravel and coarse organics, which can be used on road and railway embankments to grow some vegetation for erosion control. It is also useful as a lawn sub grade cum drainage layer, or it can be used as organic manure in tree pits. The next coarser fraction may have a lot of combustibles (cloth etc) which can be baled and supplied as AFR (Alternate Fuel Resources) in cement kilns or boilers.

h. The heavy fractions may be sand and gravel usable for road shoulders or soil/earth for plinth filling. Stones and concrete if any can be used for road sub-grade, or crushing for recycling and reuse in the construction industry.

i. About 10% will be unwanted and can be leveled on site to raise the ground level slightly for future use. Reclaimed space can be reused for waste processing or alternate non-habitation uses.

Solid Waste Management Mission

To achieve all of the above, India needs a dedicated National Urban Solid Waste Management Mission (NUSWAM) to meet 2019 deadlines for clean cities in focused mission mode.

Summary

Prevention is better than cure .Therefore lowering our consumption levels is the first step towards waste management. However with our ever increasing population and the changing demographics in terms of the increase in urban population and the population of youth , the waste management requires out of the box thinking and creative ideas to manage waste. Young people need to be made aware about the possibilities of creating business opportunities in the waste sector which can provide livelihood opportunities to millions of youth of our nation.

Model Questions

1. What preventive strategies can you suggest towards effective waste management ?

2. Explain the waste management hierarchy and what are the challenges in the implementation of each of the stages.

3. Circular economy requires the manufacturers across sectors to adopt practices such as redesigning, replacing and lengthening the life of the products . Do you agree with this statement? What challenges do you anticipate from the manufacturers /producers to follow these practices?

4. Behavioral change of stakeholders is an important step towards waste management. What can be the strategies to change the mindsets of stakeholders towards effective waste management?

References

Website of Ms. Almitra patel www. almitrapatel.com

Chapter 5 - Sustainability tools

Introduction

The sustainability tools allow the organizations to improve their environmental performances and to respect the sustainable development principles in line with the national and the global development agendas .For example the EMS helps to improve environmental performance, compliance with environmental regulations and prevent pollution and conserve natural resources and help reduce/mitigate environmental risks.

Objectives

- Explain life cycle analysis
- Identify the stages in Environment system management
- Corporate social responsibility and waste management
- Ecological footprint and carbon credit
- Extended Producer responsibility

5.1 Life Cycle Analysis

Life-Cycle Thinking and Life-Cycle Assessment (International: ISO 14040:200615) is a "Cradle to Grave" approach in which all stages of the product life is taken into account, from the supply of raw materials to the disposal of the remaining waste through manufacturing, transportation, distribution, use, etc.

Film analysis and discussions

https://www.youtube.com/watch?v=wC8MjNrLQQE

What is the challenge ?

What is the response?

What is your key learning from the waste?

The overarching idea is to reduce the overall impact on the environment and avoid shifting an issue from one stage to another. It is a support tool for decision-making that balances the potential environmental benefits and drawbacks of different options when implementing new measures, for example it can help determine if incineration might be in some cases more appropriate than recycling. In Europe, the European Commission's Integrated Product Policy Communication (COM (2003)302) identified Life-Cycle Assessment (LCA) as the "best framework for assessing the potential environmental impacts of products". Article 4 (2) Waste Framework Directive (2008/98/EC) stipulates: "When applying the waste hierarchy, Member States shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste."

In Japan, the 3rd Fundamental Plan mentions that "in promoting such recycling, we need to give importance on the view point of LCA (Life Cycle Assessment), where recycling would not end up with heavier environmental loads through a substantial increase in the consumption of required energy, with due considerations to the balance with global warming measures." Manufacturing a product can be very complex. Raw materials come from many different sources and obtaining each one of those materials involves a different series of inputs, outputs and processes, each of which has impacts on the environment. To identify the total environmental impact of a product it is necessary to do a life cycle analysis.

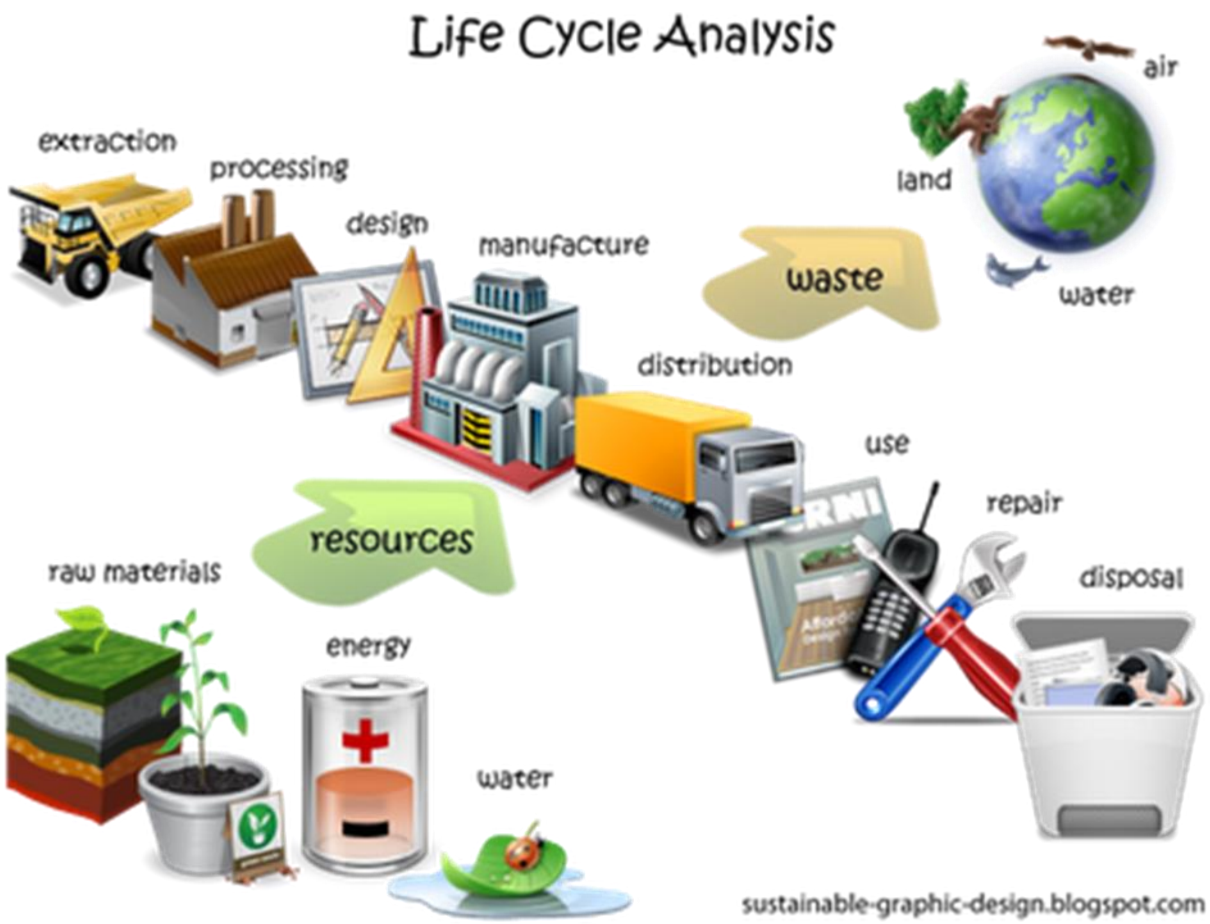


Fig 5.1 Life cycle Analysis

To examine how much a product impacts the environment, it is necessary to account for all the inputs and outputs throughout the life cycle of that product, from its birth, including design, raw material extraction, material production, part production, and assembly, through its use, and final disposal.

The first stage of a life cycle analysis is called an "inventory analysis." In an inventory analysis, the goal is to examine all the inputs and outputs in a product's life cycle, beginning with what product is composed of, where those materials came from, where they go, and the inputs and outputs related to those component materials during their lifetime. It is also necessary to include the inputs and outputs during the product's use, such as whether the product uses electricity. The purpose of the inventory analysis is to quantify what comes in and what goes out, including the energy and material associated with materials extraction, product manufacture and assembly, distribution, use and disposal and the environmental emissions that result. Green Manufacturing is a method for manufacturing that Minimizes waste and pollution. These goals are realized through product and process design. In Green Manufacturing, environmental impact of all stages of Production is considered that will not use any Materials which are harmful to the ecosystem in the design, Production, field application and end of life disposal stages of the product.

Green manufacturing involves transformation of industrial operations in three ways: (1) using Green energy; (2) developing and selling Green products; and (3) employing Green processes in business operations. A recent global survey by BCG and CII reveals that as many as 92 percent of the companies surveyed are engaged in Green initiatives. (Source: BCG & CII, 2011). In India over the past few years, both the Government and the industry have recognized the challenges posed to the country's environment by industrial growth and rapid urbanization. While India has had strict environmental protection laws for many years, the implementation has been weak at times. This scenario is changing if one goes by some of the recent high-profile cases, where companies were either denied permissions or given conditional approvals and had to commit to certain sustainability conditions.

5.2 Environment Management System

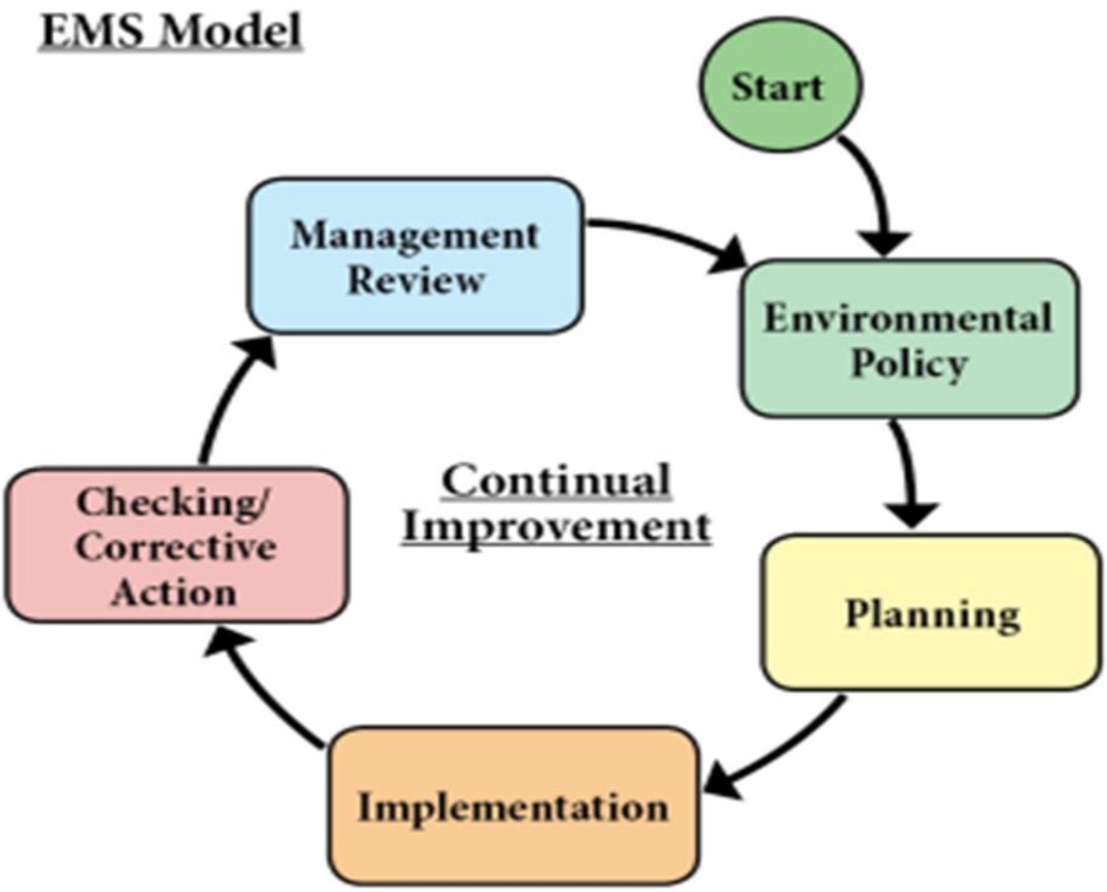
An Environmental Management System (EMS) is a framework that helps an organization achieve its environmental goals through consistent review, evaluation, and improvement of its environmental performance. The assumption is that this consistent review and evaluation will identify opportunities for improving and implementing the environmental performance of the organization. The EMS itself does not dictate a level of environmental performance that must be achieved; each organization's EMS is tailored to it's own individual objectives and targets.

An EMS helps an organization address its regulatory demands in a systematic and cost-effective manner. This proactive approach can help reduce the risk of non-compliance and improve health and safety practices for employees and the public. An EMS can also help address non-regulated issues, such as energy conservation, and can promote stronger operational control and employee stewardship.

ISO 14001 is the international standard that specifies requirements for an effective environmental management system (EMS). It provides a framework that an organization can follow, rather than establishing environmental performance requirements.

To stay competitive, organizations need a sound environmental management system (EMS).

- ISO 14001 is a globally recognized management system standard published by ISO (International Organization of Standardization).
- It provides a tried and tested framework for ensuring regulatory compliance.
- Implementing an Environmental Management System is a solid way to **identify** and **control the effects** of your company on the environment


EMS Model
Start
Management Review
Environmental Policy
Continual Improvement
Checking/ Corrective Action
Planning
Implementation


Environmental Policy
Environmental Plan
Management Review
ISO 14001
Plan Implementation
Monitoring and Corrective Actions

- **Commitment and Policy -** Top management commits to environmental improvement and establishes the organization's environmental policy. The policy is the foundation of the EMS.

- **Planning -** An organization first identifies environmental aspects of its operations. Environmental aspects are those items, such as air pollutants or hazardous waste, that can have negative impacts on people and/or the environment. An organization then determines which aspects are significant by choosing criteria considered most important by the organization. For example, an organization may choose worker health and safety, environmental compliance, and cost as its criteria. Once significant environmental aspects are determined, an organization sets objectives and targets. An objective is an overall environmental goal (e.g., minimize use of chemical X). A target is a detailed, quantified requirement that arises from the objectives (e.g., reduce use of chemical X by 25% by September 1998). The final part of the planning stage is devising an action plan for meeting the targets. This includes designating responsibilities, establishing a schedule, and outlining clearly defined steps to meet the targets.

- **Implementation -** A organization follows through with the action plan using the necessary resources (human, financial, etc.). An important component is employee training and awareness for all employees. Other steps in the implementation stage include documentation, following operating procedures, and setting up internal and external communication lines.

- **Evaluation -** A company monitors its operations to evaluate whether targets are being met. If not, the company takes corrective action.

- **Review -** Top management reviews the results of the evaluation to see if the EMS is working. Management determines whether the original environmental policy is consistent with the organization's values. The plan is then revised to optimize the effectiveness of the EMS. The review stage creates a loop of continuous improvement for a company.

Potential Benefits

- Improved environmental performance
- Enhanced compliance
- Pollution prevention
- Resource conservation
- New customers/markets
- Increased efficiency/reduced costs
- Enhanced employee morale
- Enhanced image with public, regulators, lenders, investors
- Employee awareness of environmental issues and responsibilities

5.3 CSR and Waste Management

A CSR strategy is your company's way of demonstrating to stakeholders, from customers and employees to investors and the wider public, that you are responsible and accountable for your actions. You are not an isolated economic entity – your business activities affect those around you, so you need to have policies in place to ensure minimal or positive impact.

CSR and the Environment

A key part of any CSR strategy is to minimise your company's impact on the environment. This has multiple benefits. Firstly, it can help your business to save money on energy and waste management. It can also do wonders for your company's corporate image as a responsible and eco-conscious part of the local community. Lastly and perhaps most crucially, it minimises your impact on the planet and reduces your carbon footprint.

Fig 5.4 100 most successful companies

Waste Reduction

The first step is to identify the different waste streams within your business. For example, office paper waste or waste from industrial processes. How can these waste streams be reduced? Set a realistic waste reduction target and put measures in place to achieve it.

Recycling

As well as reducing waste, is there any way you could be disposing of it more responsibly?

Switching to a recyclable alternative for certain materials or finding a greener waste management could both be viable solutions.

Changing office culture

Implement a new printing policy, where employees only print when necessary, along with other changes such as switching equipment off when not in use. You can also try recycling challenges and other behavioural change schemes within the office.

Transport

Could more meetings take place virtually or over the phone, rather than in person? This could reduce your company's carbon footprint in relation to travel, as could the implementation of a new cycle or walk to work scheme among employees.

Energy-saving Measures

These include installing insulation, energy-saving or motion-activated lighting, double glazing and many other measures – all of which are relatively easy to do but will pay for themselves over time.

Making your Products Greener

As well as making changes to the way your business operates, you can also help your customers to make more responsible choices. For example, by selling products in recyclable or reduced packaging.

How Employees can Help you to Achieve your Goals

The key to success in achieving your goals, environmental or otherwise, is to get your employees involved in making change happen. For example, you can use corporate reward schemes to motivate employees to recycle more, to cycle to work or to reward other positive behavioural changes. Once a key goal is achieved, the employee or team is rewarded. This motivates them to make your company's objectives part of their personal goals.

5.4 Ecological Footprint and Carbon Footprint

The simplest way to define ecological footprint would be to call it the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated. More simply, it is the amount of the environment necessary to produce the goods and services necessary to support a particular lifestyle. Carbon dioxide, the most important greenhouse gas produced by combustion of fuels, has become a cause of global panic as its concentration in the Earth's atmosphere has been rising alarmingly.

This devil, however, is now turning into a product that helps people, countries, consultants, traders, corporations and even farmers earn billions of rupees. This was an unimaginable trading opportunity not more than a decade ago. Carbon credits are a part of international emission trading norms. They incentivise companies or countries that emit less carbon. The total annual emissions are capped and the market allocates a monetary value to any shortfall through trading. Businesses can exchange, buy or sell carbon credits in international markets at the prevailing market price.

India and China are likely to emerge as the biggest sellers and Europe is going to be the biggest buyers of carbon credits. Last year global carbon credit trading was estimated at $5 billion, with India's contribution at around $1 billion. India is one of the countries that have 'credits' for emitting less carbon. India and China have surplus credit to offer to countries that have a deficit.

India has generated some 30 million carbon credits and has roughly another 140 million to push into the world market. Waste disposal units, plantation companies, chemical plants and municipal corporations can sell the carbon credits and make money. As nations have progressed we have been emitting carbon, or gases which result in warming of the globe. Some decades ago a debate started on how to reduce the emission of harmful gases that contributes to the greenhouse effect that causes global warming. So, countries came together and signed an agreement named the Kyoto Protocol.

The Kyoto Protocol has created a mechanism under which countries that have been emitting more carbon and other gases (greenhouse gases include ozone, carbon dioxide, methane, nitrous oxide and even water vapour) have voluntarily decided that they will bring down the level of carbon they are emitting to the levels of early 1990s. Developed countries, mostly European, had said that they will bring down the level in the period from 2008 to 2012. In 2008, these developed countries have decided on different norms to bring down the level of emission fixed for their companies and factories.

A company has two ways to reduce emissions. One, it can reduce the GHG (greenhouse gases) by adopting new technology or improving upon the existing technology to attain the new norms for emission of gases. Or it can tie up with developing nations and help them set up new technology that is eco-friendly, thereby helping developing country or its companies 'earn' credits.

India, China and some other Asian countries have the advantage because they are developing countries. Any company, factories or farm owner in India can get linked to United Nations Framework Convention on Climate Change and know the 'standard' level of carbon emission allowed for its outfit or activity. The extent to which I am emitting less carbon (as per standard fixed by UNFCCC) I get credited in a developing country. This is called carbon credit. These credits are bought over by the companies of developed countries -- mostly Europeans -- because the United States has not signed the Kyoto Protocol.

5.5 'Extended Producer Responsibility'

It is the responsibility of any producer of electrical or electronic equipment, for channelization of e-waste to ensure environmentally sound management of such waste. Extended Producer Responsibility may comprise of implementing take back system or setting up of collection centres or both and having 64 agreed arrangements with authorised dismantler or recycler either individually or collectively through a Producer Responsibility Organisation recognised by producer or producers in their EPR – Authorisation. 'EPR - Authorisation' is a permission given by CPCB to a producer, for managing Extended Producer Responsibility with implementation plans and targets outlined in such authorisation including detail of Producer Responsibility Organisation and e-waste exchange, if applicable. 'EPR Plan' is submitted by a producer to CPCB, at the time of applying for EPR - Authorisation in which a producer shall provide details of e-waste channelisation system for targeted collection including detail of Producer Responsibility Organisation and e-waste exchange, if applicable. The rules also have mentioned the EEE codes and average life of different categories of Electrical and electronic equipment, Table D23. a) Collection is now exclusively Producer's responsibility, which can set up collection centre or point or even can arrange buy back mechanism for such collection. No separate authorization for such collection will be required, which will be indicated in the EPR Plan of Producers. b) Single EPR Authorization for Producers is now being made CPCB's responsibility to ensure pan India implementation. c) Option has been given for setting up of PRO, e-waste exchange, e-retailer, Deposit Refund Scheme as additional channel for implementation of EPR by Producers to ensure efficient channelization of e-waste. d) Collection and channelisation of in Extended Producer Responsibility - Authorisation shall be in line with the targets prescribed in Schedule III of the Rules. e) The import of electrical and electronic equipment shall be allowed only to producers having Extended Producer Responsibility authorisation.

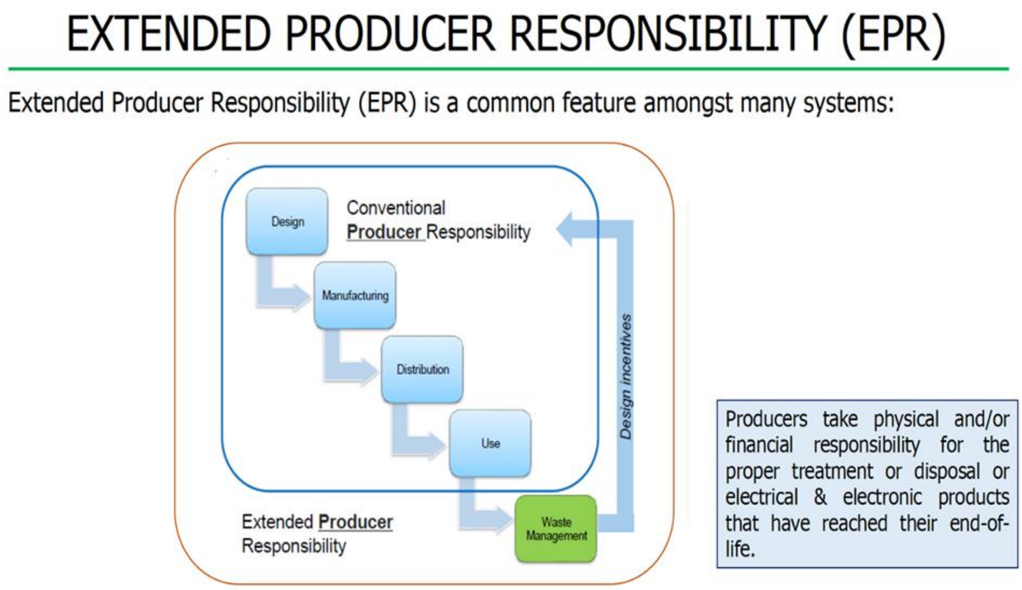


Fig 5.5 Extended producer Responsibility

Summary

Sustainability tools are important for producers to keep themselves relevant in the market They not only help businesses to minimize their negative environmental impact on the environment but also help in brand building . Extended producer responsibility, environmental management system are useful tools to enhance productivity as well as environment protection.

Model Questions

1. Explain Life cycle analysis
2. What kind of sustainability practices can corporates adopt to manage waste?
3. Write 5 caselets of CSR initiatives working towards sustainable business solutions.

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Block 2

Waste Management as Project Management and GIS

Swachhta Action Plan

Mahatma Gandhi National Council of Rural Education

Department of Higher Education

Ministry of Human Resource Development, Government of India

Hyderabad - 500004

Contents

Waste Management as Project Management and GIS – An Introduction

Project management is expanding rapidly in various fields of activity, so, it is still necessary debates and clarifications on the effective use of project management. In order "to meet" this current, were established the Project Management Institute (PMI) and the International Project Management Association (IPMA).

The project management constitutes "a macroeconomic strategy, a way to meet contemporary societies on the whole increased complexity of the external environment. Researchers in the field considers that management projects are created to serve as multidisciplinary demarches that can achieve many purposes and down menus into a limited time and in different environments (IT, agriculture, green economy, climate change, sustainable development, etc).

The main purpose of this book consists in highlighting the importance and applying project management and management strategies in waste management. This may contribute to a significant reduction of environmental pollution and, implicitly, to efficiency of the specific activities, on the other hand, expanding the horizon by reintroduction of economic cycle waste which is likely to suggest possible future developments, such as, the identification of new sources of natural fertilizer in agriculture, producing methane gas, etc. The fundamental elements of waste management are represented by generation, reduction, collection, recycling and disposal, and they lead to the identification of approaches by which to achieve the desired objectives. This is precisely why; it is necessary clear highlights of the management strategies that contribute to "stopping" the major increase in quantities of waste. In principle, the methodology for this book was based on documentation from specialized literature, and in the same time can specify that we have contributed with our information and knowledge available to identify strategies that can be applied for a better waste management.

Chapter 1- Projects in ContemporaryOrganizations

1.1 Introduction to Project Management

From the strict perspective of management, \`project\` represents a temporary organizational structure aims at achieving into a certain period of time, a defined scope, based on approaches with a strong innovative character. Project- It's a temporary group activity designed to produce a unique product, service or result (Project Management Institute, 2008). Project management, is the application of knowledge, skills and techniques to execute projects effectively and efficiently (Project Management Institute, 2008). Project management represents a modern governing characterized by the use of projects as a way of amplification to increase competitiveness, effectiveness and performance of the organization as a holistic entity.

The Project management assumes rigor in terms the formulation of objectives, the stability of activities and responsibilities, the resource allocation and deadlines (Gareis, 2005). The project management constitutes "a macroeconomic strategy, a way to meet contemporary societies on the whole increased complexity of the external environment" (Gareis, 2005). Researchers finds applications of project management in Information technology (IT), agriculture, green economy, climate change, sustainable development, etc.

Objectives

- To understand project management and Project management life cycle
- To understand Project management principles in waste management
- To understand GIs in waste management

Structure

1.1 Introduction to Project Management

1.2 Project management principles for waste management

1.3 Project lifecycle

1.4 Introduction of GIS and Remote Sensing in waste management applications

1.5 Factors influencing waste disposal site

To Do Activities

1. Recall the various types of natural resources.

2. Facilitate discussion with students, the different steps involved in Project life cycle.

3. Discuss Project management principles for waste management.

4. Discuss GIS applications in waste management

5. Explain factors affecting waste disposal site.

8. Discuss the career development aspect in Project management?

9. Discuss the research and internship opportunities in Project management sector.

10. Study an organization where project management principles are used in waste management

11. Visit an organization and write a report about how project management principles are used in that organization.

Meaning of a Project

Centuries back, so-called “projects” were finished successfully, e.g. the building of Taj Mahal at Agra, but these projects were managed more on an ad-hoc basis mostly using informal techniques and tools. Project management nowadays is regarded as a very high priority as all companies or organizations, whether small or large, are at one time or another involved in implementing new undertakings, innovations and changes etc. (Passenheim, 2009).

These projects may be individually diverse, however over time, some tools, management techniques and problem-solving approaches have proven themselves to be more rewarding than others in bringing projects to a successful end. Nowadays, almost more than ever, everybody asks for “projects” to return the world economy to its former speed.

Every project has the following characteristics (Passenheim, 2009)

- Consists of temporary activities which have predetermined start and end dates.
- Uses restricted resources.
- It has a single goal or a set of goals.
- All events are to be realized to develop a single and new output.
- Usually has a budget.
- Usually a project manager is responsible for co-coordinating all activities.

Projects are usually chartered and authorized external to the project organization by an enterprise, a government agency, a company, a program organization, or a portfolio organization, as a result of one or more of the following features

- A market demand (e.g., a consumer product company authorizing a project to develop a new cold drink with less sugar in response to an increased health awareness)
- A business need (e.g., a publisher authorizing a project to write a new book to increase its revenues)
- A customer request (e.g., an amusement park authorizing a company to develop a new roller coaster)
- A technological advance (e.g., an electronics firm authorizing a new project to develop a faster, cheaper, and smaller netbook)
- A legal requirement (e.g., Government authorizes a project to establish laws for controlling the home loan system)
- A social need (e.g., a non-governmental organizationauthorizing a project to raise the awareness of donating blood)

Process Management

A process can be defined as the constitution of links between activities and the transformation that takes place within the process (Passenheim, 2009).

Every process has the following characteristics

- **Definability** It must have clearly defined boundaries, input and output.
- **Order** It must consist of activities that are ordered according to their position in time and space.
- **Customer** There must be a recipient of the process' outcome, i.e. a customer.
- **Value-adding** The transformation taking place within the process must add value to the recipient, either upstream or downstream.
- **Embeddedness** A process cannot exist in and of itself; it must be embedded in an organizational structure.
- **Cross-functionality** A process regularly can, but not necessarily must, span several functions.

Frequently, a process owner, i.e. a person being responsible for the performance and continuous improvement of the process, is also considered as a prerequisite.

The fundamental nature of a project on the other hand is that it is a temporary endeavor undertaken to create a unique product, service, or result. Projects are distinguished from operations (and therefore also from processes) and from programs.

A project will deliver business and/or technical objectives, is made up of defined processes & tasks, will run for a set period of time, and has a budget and resources.

Project Management deals with tracking this process' execution, from a schedule and cost perspective. It includes functions for developing the optimal project schedule, producing a financial model of the project, scheduling and tracking of effort against plan, managing costs against budget, and reporting of status, to name but a few. The uniqueness of the deliverable, whether it is a product, service, or result, requires a special approach (Passenheim, 2009).

Operation

- Operations are the ongoing execution of activities that produce the same output or provide a repetitive service.
- Operations do not produce new things, but they are necessary to maintain and sustain the system.
- Operations are used to run regular business models, achieve the goals of the business, and support the business.
- Operations are different as opposed to projects, which are known for their uniqueness.
- Operations are permanent, and their only constraint is to make a profit for the organization.
- Any manufacturing or production process can be an example of an operation.

The difference between the Project and the Operation

- Projects are unique and temporary (definitive beginning and ending), while operations are ongoing and permanent with repetitive output.

- Projects have a fixed budget, while operations have to earn a profit to run the business.
- Projects are executed to start a new business objective and terminated when it is achieved, while operational work does not produce anything new and it is ongoing.
- Projects create a unique product, service, or result, while operations produce the same product, aim to earn a profit and keep the system running.

Roles of Project Manager

Effective project management techniques are important to ensure successful project performance (Passenheim, 2009).

- The appointment of the best project team will better ensure the success of the project, but the best project team must be led by a good leader, which is undoubtedly the project manager.
- Project managers play a crucial role.
- The project managers are responsible for the overall success of delivering the owner's physical development within the constraints of cost, schedule, quality and meeting the requisite safety requirements
- A project manager is one, who looks into the application of knowledge, skills, tools, and techniques to describe, Organization oversee and control the various project processes.
- The roles and responsibilities of a project manager differ from company to company
- It is important to understand what role a particular project manager will play in a certain company or organization.
- A project manager is the person who has the overall responsibility for the successful planning and execution of a project.
- He or she must have a combination of skills including an ability to ask penetrating questions, detect unstated assumptions and resolve conflicts, as well as more general management skills.
- In most cases, a single project manager is accountable for the success of a project and is responsible for its planning, allocating, directing and controlling functions.
- Ideally, each project manager would be assigned one and only one project and each project manager would have ample opportunity to use his skills to resolve all project issues.
- Project manager’s success at managing their project is dependent on their competence, particularly the leadership style comprising emotional intelligence, management focus as well as intellectual capabilities.

The Responsibilities of a Project Manager

The most important responsibilities of a project manager are

- Project evaluation,
- Setting up the team,
- Setting up systems,
- Planning,
- Monitoring, control,
- Negotiating contract conditions,
- Training
- Communication

Project manager’s success is at managing the project that is dependent on project manager’s competence, particularly the leadership style comprising emotional intelligence, management focus as well as intellectual capabilities (Passenheim, 2009).

1. A True Project Manager is responsible for effectively and efficiently
2. Defining the scope of projects Estimating project costs Gaining stakeholders’ approvals
3. Measuring project progress
4. Controlling project changes
5. Closing out projects

It is important to understand what role a particular project manager will play in a certain company or organization.

Essential skills of a Project Manager In order to meet the objectives of modern projects, which are increasingly complex in nature, it is essential for project managers to be able to use a variety of managerial skills.

Essential Skills of a Project Manager

In order to meet the objectives of modern projects, which are increasingly complex in nature, it is essential for project managers to be able to use a variety of managerial skills (Rajni Devi, 2013).

To conclude as to what are the most important knowledge and skills that a project manager should have

- **Management knowledge and skills** finance and accounting; sales and marketing; research and development; manufacturing and distributions; strategic planning; tactical planning; operational planning; organization structures; organizational behavior; personnel administration; managing work relationships.
- **Technical knowledge and skills** defined as an understanding of and proficiency in, a specific kind of activity, particularly one involving methods, processes, procedures, or techniques.
- **Business knowledge and skill** on small projects, this can be a tough challenge because project managers are also managing the project control function.
- **Human knowledge and skills** the ability to work with and through other people.

Benefits of Project Management

The main advantage of project management is that is helps you to manage your projects effectively, enabling you to resolve problems more quickly. It takes time and money to manage a project, however following good practices can help you

- improve your chances of achieving the desired result
- gain a fresh perspective on your project, and how it fits with your business strategy
- priorities your business’ resources and ensure their efficient use
- set the scope, schedule and budget accurately from the start
- stay on schedule and keep costs and resources to budget
- improve productivity and quality of work
- encourage consistent communications amongst staff, suppliers and clients

- satisfy the various needs of the project's stakeholders
- mitigate risks of a project failing
- increase customer satisfaction
- gain competitive advantage and boost your bottom line

1.2 Project Management Principles for Waste Management

Sustainable Development Goals and Waste Management Connect (Silviu , 2016)

- Sustainable Development means 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.
- At the World summit on Sustainable Developments in 2002, Johannesburg, South Africa, governments reaffirmed the importance of solid waste management.
- They called for priority attention to be given to waste prevention and minimization, reuse and recycling. They also called for the developments of environmentally sound disposal facilities, including technology to convert waste into energy.

Waste is a global issue; if it is not properly dealt with, it poses a threat to public health and the environment. It is a growing issue linked directly to the way society produces and consumes. It concerns everyone. Waste management is one of the essential utility services underpinning society in the 21st Century, particularly in urban areas.

Waste management is a basic human need and can also be regarded as a basic human right. Ensuring proper sanitation and solid waste management ranks alongside the provision of potable water, shelter, food, energy, transport and communications; all are essential to society and to the economy as a whole. Despite this, the public and political profile of waste management is often lower than other utility services. Unfortunately, the consequences of doing little or even nothing to address waste management can be very costly to society and to the economy overall.

The goal is to move the fundamental thinking away from "waste disposal" to "waste management" and from "waste" to "resources" — hence the updated terminology "waste and resource management" and "resource management", as part of the "circular economy".

Waste management is an issue that impacts many parts of society and the economy. It has strong linkages to a range of other global challenges such as health, climate change, poverty reduction, food and resource security and sustainable production and consumption. The political case for action is significantly strengthened when waste management is viewed as an entry point to address a range of such sustainable development issues, many of which are difficult to tackle

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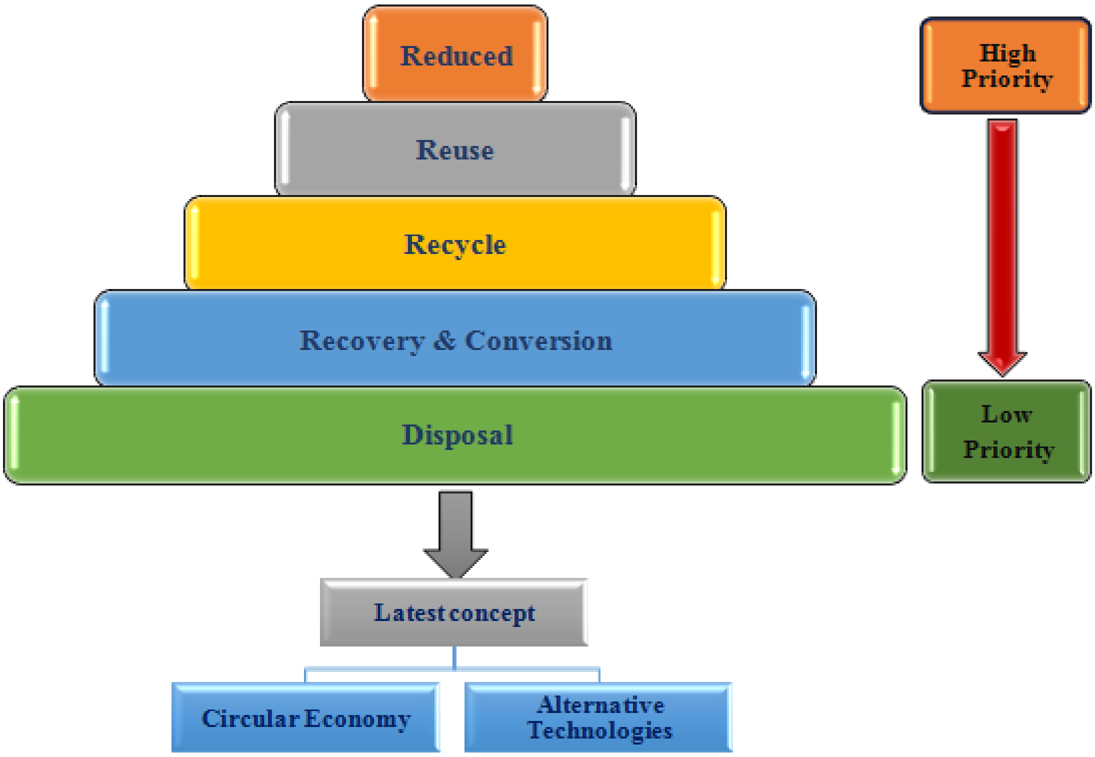

Fig.1.1 Schematic Representation of Waste Management Project Concept Hierarchy (Silviu, 2016)

Waste management is well embedded within the Sustainable Development Goals (SDGs), being included either explicitly or implicitly in more than half of the 17 goals. Thus a strong argument can be made for the strategic importance of improving waste management, insofar as actions here will contribute to progress towards a range of SDG targets. Setting and monitoring global targets for waste management will thus contribute significantly to attaining the SDGs.

National strategies with regard to budgetary and capacity support need to be aligned with the waste management issues of local and regional authorities which in turn shall result in greater participation and outcomes. Also aim should be reducing the waste generation and increasing the resource efficiency. Fig 1.1 shows schematic representation of project waste management plan and which the priority phases in its implementation are.

➢ **Sustainable developments goals and Solid Waste management (SWM) (Silviu , 2016)**

- Solid waste management (SWM) is a key utility service that generally goes by unnoticed if it functions properly.
- However, if it does not function well, SWM keeps drawing public, political, and media attention in the country.
- If SWM completely stops functioning, the situation amounts to a crisis and reaches the headlines internationally.
- As such, SWM is a crosscutting issue that affects and impacts various areas of sustainable development in each of the three sustainability domains ecology, economy, and society.
- The affected areas include living conditions, sanitation, public health, marine and terrestrial ecosystems, access to decent jobs, as well as the sustainable use of natural resources.
- Accordingly, out of 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for

Sustainable Development, adopted by the 193 UN Member States in September 2015 [6], at least 12 SDGs and their pertinent targets have a direct link to SWM.

- The crosscutting nature of SWM and its impact 12 SDGs should only emphasise the importance and increase the priority of SWM (Silviu,, 2016).
- The importance and purpose of applying project management waste recycling activities
- Applying waste management may contribute to a significant reduction of environmental pollution and, implicitly, to efficiency of the specific activities (Silviu , 2016).
- Expanding the horizon by reintroduction of economic cycle waste which is likely to suggest possible future developments, such as, the identification of new sources of natural fertilizer in agriculture, producing methane gas, etc.
- The fundamental elements of waste management are represented by generation, reduction, collection, recycling and disposal, and they lead to the identification of approaches by which to achieve the desired objectives. This is precisely why, it is necessary clear highlights of the management strategies that contribute to "stopping" the major increase in quantities of waste.

➢ **Management strategies applicable to the environmental field (Silviu , 2016)**

- Implementing an environmental management project should "flow" naturally from a series of prior fundamentals.
- In the situation that the arguments in favor of execution an environmental project are not sustainable, there is a risk of failure and, as such, the smartest decision would be to stop using it.
- On the other hand, surrounding environment could be affected from achieving the objectives for any purpose, and the initial state cannot be regained than with major investments.
- Certainly, the project manager has the main responsibility for the measures adopted, but, the consequences we will support all of us. So, long-term vision and, consequently, a strategy thoroughly substantiated, are not only necessary, but, also mandatory in such situations.
- Therefore, in projects management "authors directly involved" - managers are responsible for achieving the set objectives and overall responsibility towards society and the environment. Nowadays, in such of approaches, the emphasis is on creating and developing green solutions that improve environmental quality.
- Traditional methods used have had a negative impact on the environment, it is therefore needed "refreshing" strategies.
- In all countries it is desired "green economy" that would lead to reduction and elimination of waste generated.
- One of the measures beneficial to the environment is to reduce energy consumption.
- In particular, this measure is successfully applied in business because it can reduce the costs of companies / institutions. Thus, for a long-term business is an essential condition for maintaining the business market.
- By using specific programs can be implemented measures to improve eco-efficiency in energy.
- In order to establish the main objective of environmental management, this is represented by current production management process, which ensures effective production combined with environmental protection, implicitly, of the environment man`s coexistence with rational using of natural resources.

- **Management strategies applicable to waste recycling (Silviul., 2016)**

A product used after a certain time may be eliminated or recycled thereby contributing to the achievement of environmental objectives. The private companies or state government by adopting green solutions can increase their profits, also, could design systems to reuse biodegradable waste without harming the natural ecosystem. Further, we present the principles that can be applied concerning recycling and disposal, namely

- **Waste Recycling efficient and economical**

Waste recycling is a essential point in the development and sustainability of a community, but it can become unproductive if the costs of energy, materials and others exceed the production values of products made from new materials

- **Minimizing and eliminating the volume and quantity of waste from landfills**

In this way, are proposed alternative solutions for compacting waste because landfills are not a sustainable solution? For example, some products may be reused for a different purpose, namely waste tires can be used as a protective barrier seaports, tracks, etc.

- **Creating suitable channels collection and transport to locations where waste can be reused**

In the production process of materials are necessary several manufacturing steps, and some materials collected may be beneficial in the production of other goods. In this way, instead of depositing the waste we may transform into usable products.

- **Principles and strategies for project management in organic waste recycling (Silviu , 2016)**

- In principle, an efficient waste management begins with preventing or minimizing waste generation, but if quantities of waste are produced when identifying solutions to managing the situation and intervenes through treatment. Besides the existence of present policies, approaches are needed ecological awareness must be promoted for carefully the use of natural resources.
- In essence, it is important for organizations to focus on developing strategies using flexible and practical methods.
- In urban areas, try it awareness on recycling of waste and household waste as fertilizer use in their own households because "organic waste can be beneficial nutrients for animal / plant, soil and fuel" (Dulac, 2001).
- Therefore, by implementing management projects may be introduced local and national markets. Also, waste must be sorted according to their time necessary for degradation or state in which we want them to reach for the manufacture of other products. However, must take into account that is necessary an government intervention and financial regulators.
- Thus, is at the discretion of each country to choose the best method for managing organic waste. Therefore, clear standards are needed to specify that organic waste can be reused in special areas, like compost.
- Project management and implementation of management strategies extensively documented in recycling of waste can be a powerful tool to professionalize the specific

approaches from waste recycling.

- Through this would be obtained a significant reduction in environmental pollution and, implicitly, to a more efficient specific activities.
- Complementary to the reintroduction of systematic economic circuit of waste would lead to a better capitalization of this resource.
- As such, project management implemented certain to give long-term effects requires a more sustained focus on the effectiveness of methods applied and environmental practices to all fields.

Context Based Approach in Managing Waste

Context based approaches of managing wastes involves measurement, management and reporting of waste management practices which in turn impacts resource management and efficiency, providing quality service to stakeholders and enhancing the overall wellbeing.

The context based approach of managing waste involves long term goals

1. Creating efficiency
2. Changing the culture of waste handling and awareness to varied stakeholders.
3. Innovating new solutions
4. Application of advanced technology for day to day operations.

The following are the context based approaches in managing wastes

1. Strategy based approach of waste management
2. Life cycle based approach of waste management
3. Market based or economic based approach of waste management

1. Strategy Based Approach of Waste Management

- Strategy based approach is necessary, as the key challenge towards resolving waste issues is data.
- This approach involves mapping the flow of wastes and recyclable materials and getting where maximized data availability exists.
- It helps in policy, regulation and development.
- A good data helps waste management planners and personnel's have a better waste market status which in turn will enable better network base with stakeholders and addressing waste issues.

2. Life Cycle Based Approach of Waste Management (Fig. 1.2)

Life cycle of managing waste initiates from the time it is generated includes

- waste preventive measures in operations,
- production of product depends upon demand and supply,
- recovery of material (recycling) or converting waste into energy
- Deriving benefits and avoiding emissions and adverse impacts.

Fig. 1.2 Schematic Representation of Life Cycle Based Approach (Silviu, 2016)

Life cycle assessments (LCA) steps include assessing the emissions, resources consumed and pressures on health, environment and safety that can be attributed to a product or services. In addition, LCAs also include social (e.g., employment), economic (e.g., costs) and sustainability-related considerations.

Most of the countries have "eco-labels" as a broad approach for addressing the consumption and towards managing wastes. Green label scheme has been implemented that established product criteria and certified products that have a lower impact on the environment compared to other products serving the same function.

3. Market or Economic Based Approach of Waste Management

Market based approach or so to say market based instruments refers to three context approaches of economic policy 1. packaging taxes 2. Deposit-refunds and 3.Marketable permits. Economic based approach objective is a sound public policy that maximizes environmental and societal benefits. The economic approach is concerned with influencing behavior of organization or consumer, so as to reduce pollution and improve environment. For example, if plastic bags are not charged, people and organizations will not limit its use, these in turn choke drains; affect environment and results in incurring cost of cleaning up.

These costs are referred as external costs or externalities. This ultimately is a reflection of market failure. On the other hand, when the plastic bag gets charged as it is happing in current scenarios, the level of awareness increases, its usage becomes reduced and results in reduced expenditure on management and reach to landfill.

As the saying goes "Today waste is yesterday's product and tomorrow's waste is today's product, with new waste management approaches set and delayed reach to landfills of waste and alternating it with reuse and recycling policies – business opportunity has speeded up in waste economy.

For value creation, waste has to be seen as a resource. The key to value creation is how waste is extracted, recycled and brought into revenue model for employment opportunities.

Project Management in Waste Management

The figure 1.3 below represents schematically the over concept workflow before detailing the waste management project design, monitoring, measuring, verification and reporting happens. For example, if we consider project management and management of strategies in recycling waste, the outcome would be significant reduction of environmental pollution, improving resource efficiency, creating market for valuables from wastes and employment opportunities.

1. Here strategies for project management include
2. Waste recycling to be efficient and economical,
3. Minimizing and eliminating the volume and quantity of wastes from landfills
4. Creating suitable networks for collection and transport of wastes to locations where waste can be reused and recycled.

5. When there is effective cooperation between stakeholders implementation of successful waste management plan becomes pertinent.
6. Also while promoting waste recycling and cooperation between the different stakeholders

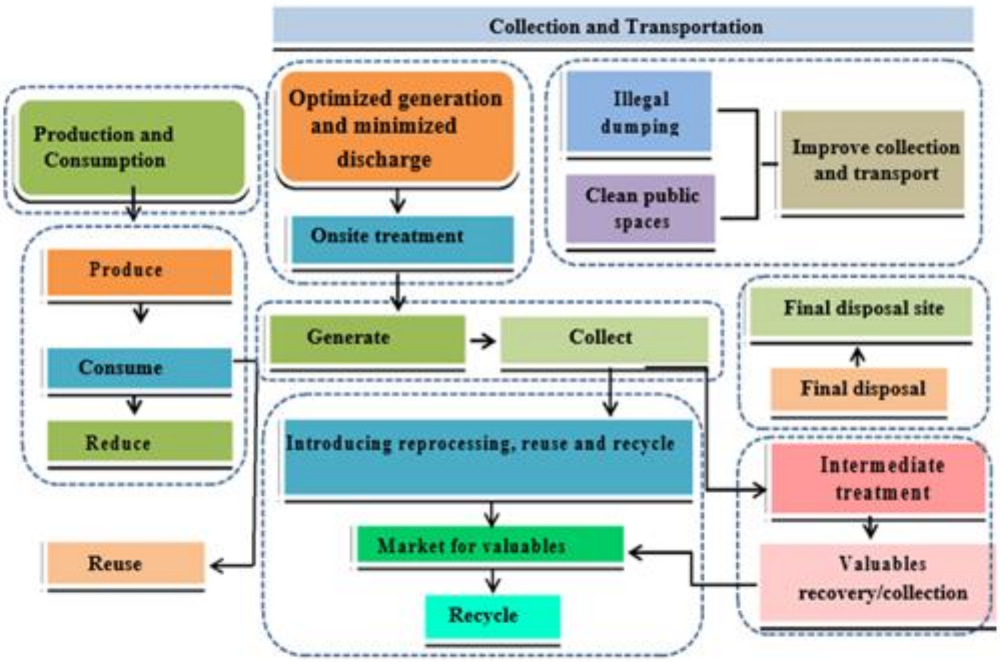

Fig. 1.3 Project Management Conception– Waste Management hierarchy (Source Phillips, 2010)

1.3 Project Management life Cycle

The project management life cycle provides a framework for managing any type of project. A project has a definite beginning and end (Fig. 1.4). Between the beginning and end points, the project can be divided into four phases.

- Project Initiation
- Project Planning
- Project Execution
- Project Closure

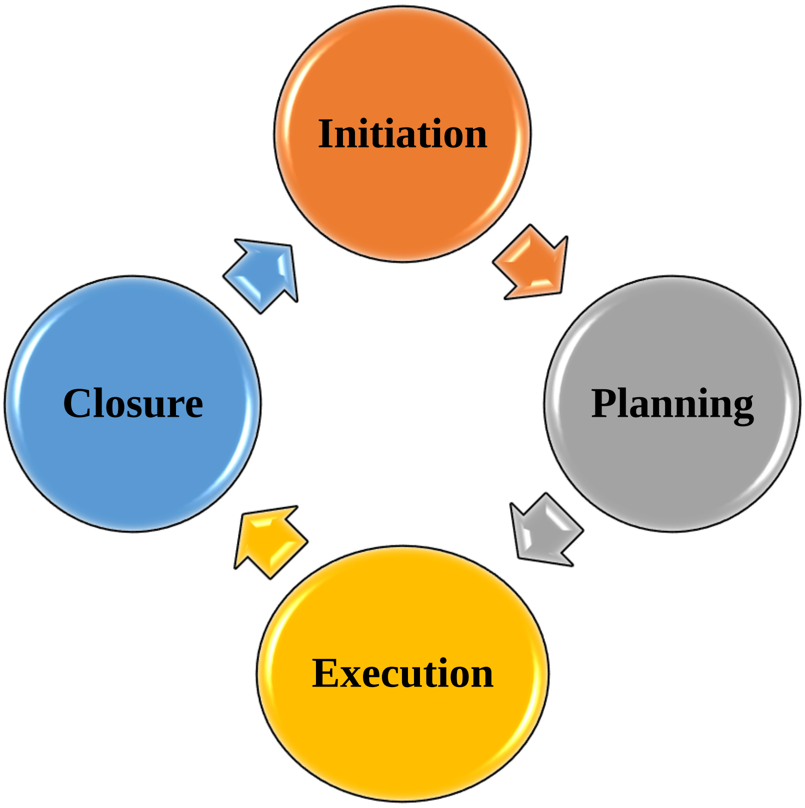

Fig. 1.4 The Project Management Life Cycle (Source Phillips, 2010)

Let's take a closer look at each phase of the *project life cycle*.

Project Initiation

The purpose of the *Project Initiation* Phase is to define and authorize the project. The initial definition of the project can come from several places:

- Project Statement of Work (SOW)
- Business Case
- Contract

The project manager takes the information provided and creates a Project Charter. The Project Charter authorizes the project and documents the initial requirements for the project.

It generally includes information such as:

- Project purpose, vision, and mission
- Measurable objectives and success criteria
- High level project description, requirements, and risks
- Summary milestone schedule and budget
- Name and authority of the project sponsor

An important part of starting your project off right is performing a *stakeholder analysis*. Understanding which people or organizations will be impacted by or can influence your project is critical for ensuring your project's success.

Project Planning

The purpose of the *Project Planning* Phase is to determine the approach you will take and define all the details of how the project will be done.

Project Planning has two parts:

- Strategic Planning
- Implementation Planning.

During *Strategic Planning* you develop the overall approach to the project. During *Implementation Planning* you figure out all the details of how the project will be done.

A good way to visualize this is to think of your project as a family vacation.

- During Project Initiation you determine where you want to go (your mission).
- During Strategic Planning, you decide whether you want to fly there or drive (your approach).
- Let's say you decide to drive. In that case, during Implementation Planning you would map out your route, identify which hotels you will stay at along the way, determine how long each leg of the trip will take, and so on (all the details).

Project Execution

The purpose of the *Project Execution* Phase is to carry out the activities defined during the Project Planning Phase.

Project Execution is where most of the time, money, and people are used on a project. This is where the action takes place.

During this phase of the *project management life cycle* the project manager has to keep all the activities moving forward in a coordinated manner. This means you will need to track the progress of each activity and adjust your plans when the situation changes. This tracking and adjustment of project activities is also known as Monitor and Control.

During the execution phase all of the agreed project deliverables should be implemented and accepted by the customer. The customer can be an internal customer or an external customer.

Project Closure

The purpose of the *Project Closure* Phase is to formally close the project.

During Project Closure, there are several key activities that need to be performed...

- Verify that the completion criteria are met
- Create a project closure report
- Collect and archive project artifacts
- Perform a project postmortem

Many projects skip this phase. Once the Execution Phase is complete, they simply move on. It's unfortunate since they really don't know if the project objectives have been met, don't organize the project artifacts to be easily found for future project's reference, and don't identify the key issues and lessons learned by the project that can be applied to future projects.

Performing Project Closure will benefit both your company and your career. If you do this well, you will set yourself up to lead high-visibility, business-critical projects. So make sure your projects go through the full project management life cycle.

1.4 Introduction of Geographic Information System (GIS) and Remote Sensing in Waste Management Applications

Geographic Information System (GIS)

GIS is a powerful software technology that allows a virtually unlimited amount of information to be linked to a geographic location (Fig. 1.5). Coupled with a digital map, GIS allows a user to see locations, events, features, and environmental changes with unprecedented clarity, showing layer upon layer of information such as environmental trends, soil stability, pesticide use, migration corridors, hazardous waste generators, dust source points, Lake Remediation efforts, and at-risk water wells (Fig. 1.6).

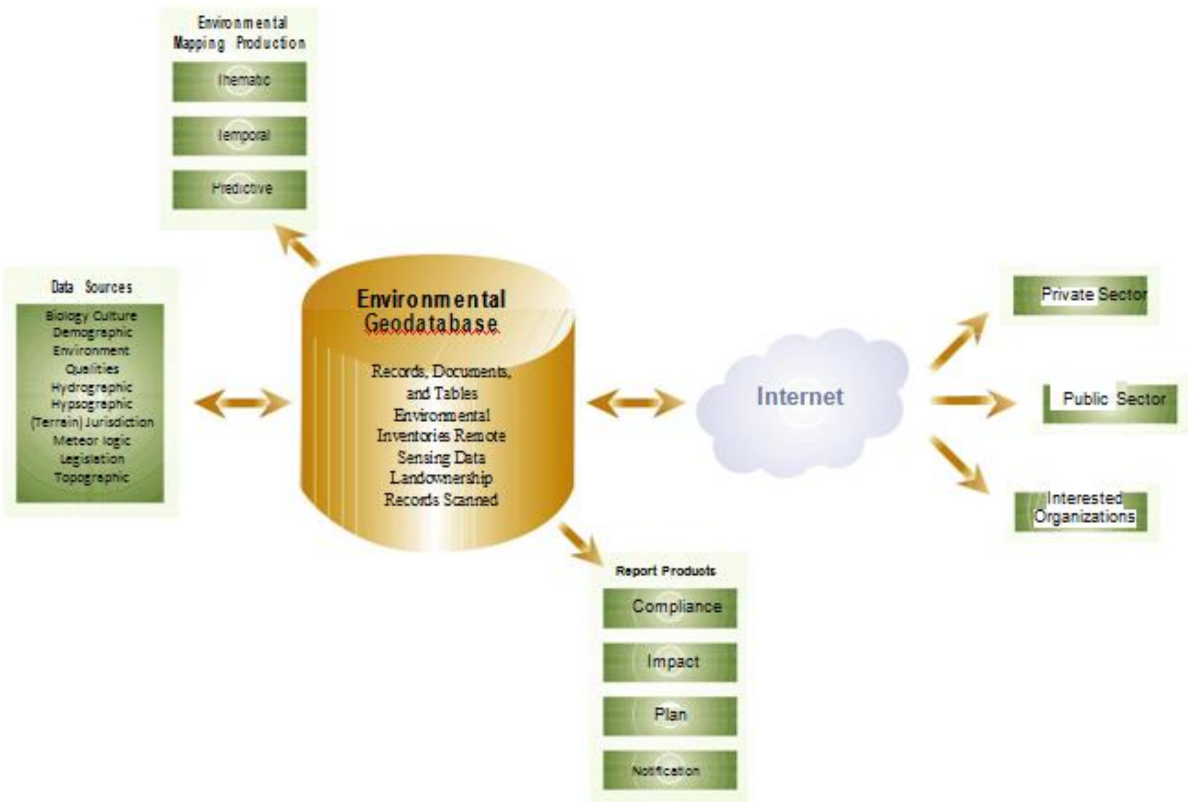

Fig 1.5 - GIS for Environmental Management

Effective environmental practice considers the whole spectrum of the environment. ArcGIS® technology offers a wide variety of analytical tools to meet the needs of many people, helping them make better decisions about the environment. A Geographic Information System (GIS) is a computer tool for capturing, storing, querying, analyzing and displaying spatial data from the real world for a particular set of purposes. This technique is used to generate optimal route for collecting solid waste.

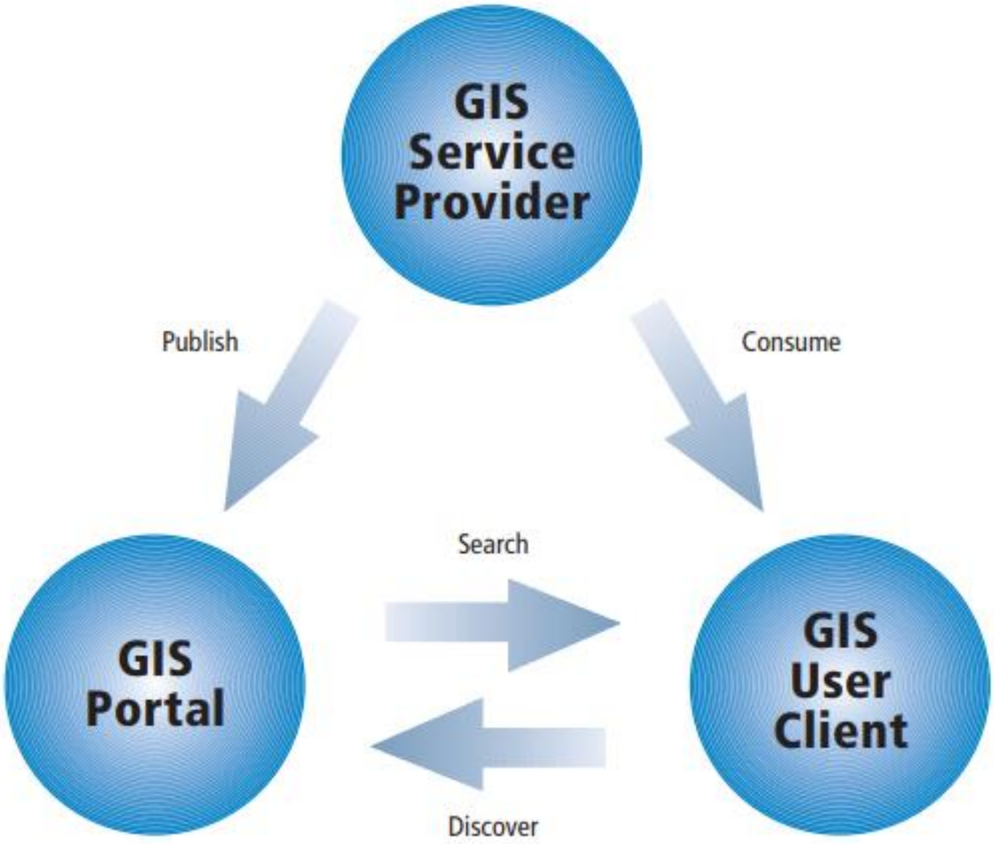

Fig 1.6 - The Flow of Information from the service provider to the user via a GIS portal

GIS is a tool that not only reduces time and cost of the site selection, but also provide a digital data bank for future monitoring program of the site.

Need of GIS in Waste Management (Taleb, 2007)

- The issue of waste is not only because of increase quantities but also largely because of inadequate management system”. One of the major management issues in solid waste management is improving methods for interpretation of data (Chalkias and Katia Lasaridi, 2011).
- Billions spent in improving scientific methods for interpretation of data, but the steps involved in the said area are much demanding”.
- Almost all of factors related to solid waste management have a spatial component as well as non-spatial data.
- Manual methods used for analysis of many factors are lengthy and tedious work and in some problems it will be difficult to solve them without the aid of computer software, e.g. optimization software, and also there is possibility of merging spatial and non-spatial data.
- In most cases solid waste data and records are not managed properly and are often lie in isolated form.

- Because of the improper management of the data and records, it becomes difficult to assess system functionality and efficiency.
- For proper management it is important to manage the data in an integrated way so the complexity of various systems could be reduced to solve various interrelated issues.
- Hence the need for geographic information system (GIS) arise, since GIS helps in dealing with several factors simultaneously which need to be considered while planning waste management, and because of layers property of GIS there is least chance of confusion and error, and it is capable to coordinate between spatial and non-spatial data.
- Also in GIS information can be related spatially, exchanged, compared, evaluated, and processed with a very good flexibility (Reddy and Padmaja, 2007).
- GIS is a system designed to allow user to collect, manage, analyze, and retrieve large volume of spatially referenced data and associated attribute data collected from a variety of sources

Use of GIS in Waste Management

One of the most important applications of GIS is the display and analysis of data to support the process of environmental decision-making. A decision can be defined as a choice between alternatives, where the alternatives may be different actions, locations, objects, and the like. For example, one might need to choose which the best location for a hazardous waste facility is or perhaps identify which areas will be best suited for a new development.

The role of GIS in solid waste management is very large as many aspects of its planning and operations are highly dependent on spatial data. In general, GIS plays a key role in maintaining account data to facilitate collection operations. In this manner, aspects such as customer service; analyzing optimal locations for transfer stations; planning routes for vehicles transporting waste from residential, commercial and industrial customers to transfer stations and from transfer stations to landfills; locating new landfills and monitoring the landfill, are important.

GIS is a tool that not only reduces time and cost of site selection, but also provides a digital data bank for future monitoring programme of the site (Upasna& M. S. Natwat , 2003). GIS can also play an important role in the long term environmental monitoring of closed landfill sites. Geographic Information Systems (GIS) is a relatively young field, with antecedents that go back hundreds of years in the fields of cartography and mapping. Today, GIS provides a digital way for storing, retrieving, manipulating, analyzing, and displaying geographically referenced data. Since GIS has the potential of including ecological, biological, demographic, or economic information, it becomes a valuable tool in the environmental and engineering sciences (Chalkias and Katia Lasaridi, 2011).

People in the environmental management community use GIS to organize existing information and communicate that information throughout their organizations. GIS can be used as a strategic tool to automate processes, transform environmental management operations by garnering new knowledge, and support decisions that make a profound difference on our environment. GIS is considered enterprise if, by design, it is part of the overall information technology architecture of the organization.

Introduction to ArcGIS

ArcGIS is a scalable family of software comprising a complete GIS, built on industry standards that is rich in functionality and works out of the box. Desktop GIS

- Arc Reader allows anyone to view, explore, and print ESRI published map files. It is designed for viewing and sharing maps that access a wide variety of data.

- ArcView focuses on comprehensive data use, mapping, and analysis.
- Arc Editor adds advanced geographic editing and data creation.
- Arc Info is a complete, professional desktop GIS containing comprehensive functionality including geoprocessing tools.

ArcGIS Engine is a set of core software components and tools. It is a resources package for developers to build custom GIS and mapping applications. ArcGIS can be integrated with most standard corporate systems such as work management, customer service, and reporting systems.

Both GIS functionality and data accessing ability can be embedded directly into other agency applications. GIS workflow applications simplify and automate procedures within environmental management operations, resulting in improved efficiency and significant time savings. ESRI software developers and business partners work together to bring the environmental management community benefit and value from GIS.

This value comes from

- Database-sharing architecture that supports decision making and daily work tasks
- Interoperable system solutions for integrated workflow and data access
- Internet mapping solutions that support interagency collaboration projects
- Quality control processes that ensure accurate, high-quality data
- Worker-friendly designs that increase agency-wide access and application
- Scalability that supports and adapts to growing and evolving IT demand

GIS Based Approach of Managing Wastes

The combined use of GIS with advanced related technologies (e.g., Global Positioning System – GPS and Remote Sensing - RS) assists in the recording of spatial data and the direct use of these data for analysis and cartographic representation.

As mentioned above, the most widespread application of GIS supported modelling on waste management lies in the areas of landfill siting and optimization of waste collection and transport, which are discussed in detail in the following section. Additionally, GIS technology has been successfully used for siting of recycling drop-off centers (Chalkias and Katia Lasaridi, 2011), optimizing waste management in coastal areas (Sarptas et al., 2005), estimating of solid waste generation using local demographic and socioeconomic data (Ramswamy, et al., 2003), and waste generation forecasting at the local level (Chalkias and Katia Lasaridi, 2011).

GIS-based Modeling for Landfill Selection

The allocation of a landfill is a difficult task as it requires the integration of various environmental and socioeconomic data and evolves complicated technical and legal parameters. During this process the challenge is to make an environmentally friendly and financially sound selection. For this purpose, in the last few decades, many studies for landfill site evaluation have been carried out using GIS and multicriteria decision analysis), GIS in combination with analytic hierarchy process (Saaty, 1980) – AHP, GIS and fuzzy systems, GIS and factor spatial analysis , as well as GIS-based integrated methods (Sumathy et al., 2008).

A large fraction of these applications produce binary outputs while most recent ones aim at evaluating a ”suitability index” as a tool for ranking of the most suitable areas (Kontos et al., 2005).

The main steps of a typical GIS – based landfill allocation model (Fig.1.7) are as following.

1. Conceptualization of the evaluation criteria and the hierarchy of the landfill allocation problem. This step is dedicated to the selection of the criteria related to the problem under investigation.
2. Creation of the spatial database. Here, the development of GIS layers for the modelling is implemented. These layers correspond to the primary variables.
3. Construction of the criteria – layers within the GIS environment. Criteria maps are primary or secondary variables.
4. Standardization of the criteria – layers. This step includes reclassification of the layers in order to use a common scale of measurement. Most often, the ordinal scale is used.
5. Estimation of the relative importance for the criteria. This estimation is implemented by weighting, e.g. with the use of Analytic Hierarchy Process (AHP) and pair wise comparison between variables.
6. Calculation of the suitability index. A standard procedure for this step is the weighted overlay of the standardized criteria/layers.
7. Zoning of the area under investigation is the next phase of the modelling. This classification action is based on the suitability index and reveals the most suitable areas for the application.
8. Sensitivity analysis and validation of the model.
9. Final selection – land evaluation.

The main advantages of applying GIS technology in the landfill siting process are "the selection of objective zone exclusion process according to the set of provided screening criteria, the zoning and buffering function, the potential implementation of 'what if' data analysis and investigating different potential scenarios related to population growth and area development, as well as checking the importance of the various influencing factors etc., the handling and correlating large amounts of complex geographical data, and the advanced visualization of the output results through graphical representation.”

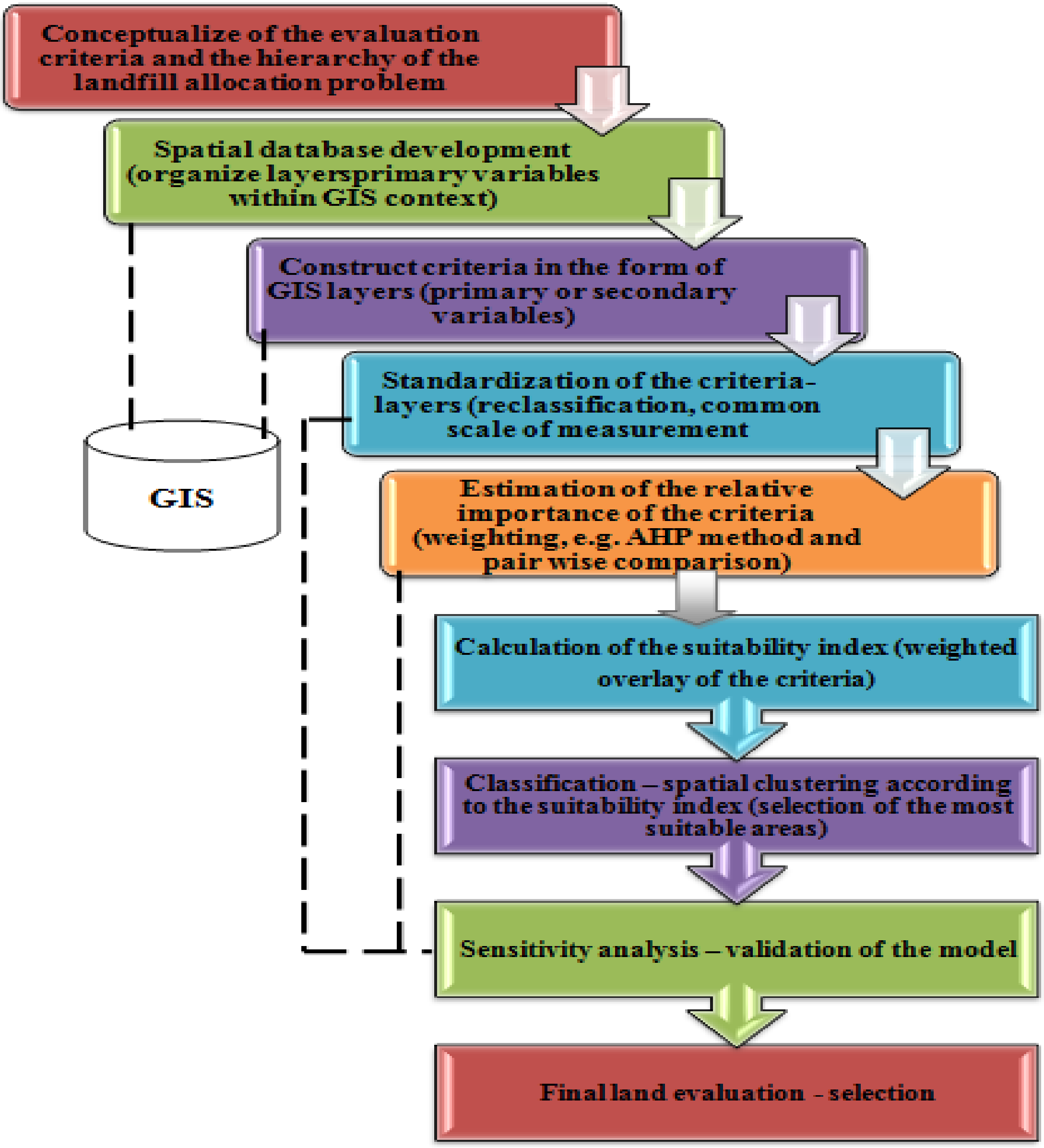

Fig. 1.7 Landfill site selections - A GIS approach (SourceChalkias and Katia Lasaridi, 2011)

Benefits of GIS

- GIS environmental management solutions enable organizations to
- Ensure accurate reporting with improved data collection.
- Improve decision making.
- Increase productivity with streamlined work processes.
- Provide better data analysis and presentation options.
- Model dynamic environmental phenomena.
- Create predictive scenarios for environmental impact studies.
- Automate regulatory compliance processes.
- Disseminate maps and share map data across the Internet.

Application of GIS

- Wild Land Analysis
- Emergency Services like Fire Prevention
- Hazard Mitigation and Future planning
- Air pollution & control
- Disaster Management
- Forest Fires Management
- Managing Natural Resources
- Waste Water Management
- Oil Spills and its remedial actions
- Sea Water – Fresh water interface Studies
- Coal Mine Fires

1.5 Factors Influencing Waste Disposal Site (Zhujie Chu et al. , 2016)

Following factors should be taken into account while selecting waste disposal site

1. Distance from airport 3000m from the end of any airport runway or landing strip in the direct line of the flight path and within 500m of an airport or airfield boundary. This is because landfills attract birds, creating the danger of aircraft striking birds
2. Areas below the 1 in 50 year flood line. This eliminates wetlands, vleis, pans and flood plains, where water pollution would result from waste disposal
3. Areas in close proximity to significant surface water bodies, e.g. water courses or dams. Unstable areas.
4. Sensitive ecological and/or historical areas. These include nature reserves and areas of ecological and cultural or historical significance.
5. Catchment areas for important water resources. Although all sites ultimately fall within a catchment area, the size and sensitivity of the catchment may represent a Fatal Flaw, especially if it feeds a water resource.
6. Areas characterized by flat gradients, shallow or emergent ground water, e.g. springs, where a sufficient unsaturated zone separating the waste body and the ground water would not be possible. Areas characterized by steep gradients, where stability of slopes could be problematic.
7. Areas of ground water recharges on account of topography and/or highly permeable soils.
8. Areas overlying or adjacent to important or potentially important
9. Areas characterized by shallow bedrock with little soil cover. These are frequently also associated with steep slopes, which may be unsuitable.
10. Areas in close proximity to land-uses which are incompatible with landfilling.
11. The economies of scale. Larger sites are economically more attractive.
12. The distance of the landfill from the waste generation areas. This is directly proportional to transport costs.
13. The size of the landfill. In general, if it is to be economical, the landfill must cater for the disposal of the waste stream over at least the medium term to justify the capital expenditure.

14. Access to the landfill site. This has cost, convenience and environmental implications, especially if roads have to be constructed.
15. The availability of on-site soil to provide low cost cover material. Importation of cover increases operating costs. Furthermore, cover shortage may reduce site life.
16. The quality of the on-site soil. Low permeability clayey soils on site will reduce the cost of containment liners and leachate control systems.
17. Exposed or highly visible sites. High visibility will result in additional costs being incurred for screening.
18. Land availability and/or acquisition costs. These are often dependent on present or future competitive land-uses, such as agriculture, residential or mining.
19. The distance to ground or surface water. The greater this distance, the more suitable the site is in terms of lower potential for water pollution.
20. The importance of ground or surface water as water resources. The greater the resource value of the water, the more sensitive the establishment of a landfill on account of the potential for water pollution.
21. The depth of soil on the site. The greater the availability of soil, the more cost-effective it will be for the landfill to meet the Minimum Requirements for operation. The landfill will thus be more acceptable in terms of cover material and therefore control of nuisances.
22. The quality of on-site soil. Low permeability soils reduce pollutant migration and are therefore favoured.
23. Valleys where temperature inversion could occur. This could promote the migration of landfill gas and odours into populated areas.
24. The sensitivity of the receiving environment. The development of a site in a disturbed environment, such as derelict mining land, would be preferable to a development in a pristine environment

Summary

Project management and implementation of management strategies extensively documented in recycling of waste can be a powerful tool to professionalize the specific approaches from waste recycling. Through this would be obtained a significant reduction in environmental pollution and, implicitly, to a more efficient specific activities. Complementary to the reintroduction of systematic economic circuit of waste would lead to a better capitalization of this resource. In order to improve current practice in the field of recycling waste are required thorough preliminary analysis on the socio-economic and environmental environment. As such, project management implemented certain to give long-term effects requires a more sustained focus on the effectiveness of methods applied and environmental practices to all fields. Therefore it is necessary to make changes in mentality in this area, the traditional approach proved ineffective against the principles of sustainable development. Also, to promote awareness and implementation of measures to reduce organic waste quantities, the state institutions should be the key factor. The project manager plays an important role influencing environmental activities. The project manager focuses on analysis of the economic analysis of the project. In order to improve the sustainability of the project, project manager should cooperate with policy makers. Currently, there is a tendency for innovation management processes in waste recycling that ensure economic performance. However, should be avoided the high costs of recycling processes because investors seek the cheapest offers for profit.

Chapter 2- Project Selection Techniques

Objectives

- To understand project selection techniques
- To understand Project charter process
- To understand various planning tools

Structure

2.1 Project selection methods and criteria

2.2 Project Charter development

2.3 Project resources and scheduling

2.4 Building a project schedule

2.5 Project Planning Tools

To Do Activities

1. Explain various project selection techniques by taking suitable examples
2. Explain project charter development
3. Explain PERT by taking suitable method
4. Discuss various scheduling techniques
5. Discuss Gantt chart with suitable example.
6. Visit a company and study it's a project charter and project scheduling. Make a report.
7. List out the factors for making a project successful by making a questionnaire.

2.1 Project Selection Criteria (Meredith and Mantel, 2012)

Organizations are flooded with opportunities, but of course, no organization enjoys infinite resources to be able to pursue every opportunity that presents itself (Pinto, 2010).

Choices must be made, and to best ensure that they select the most viable projects, many managers develop priority systems—guidelines for balancing the opportunities and costs entailed by each alternative.

The goal is to balance the competing demands of time and advantage.

The pressures of time and money affect most major decisions, and decisions are usually more successful when they are made in a timely and efficient manner

Thus organizational decision makers develop guidelines—selection models that permit them to save time and money while maximizing the likelihood of success. A number of decision models are available to project managers responsible for evaluating and selecting potential projects. As you will see, they run the gamut from qualitative and simple to quantitative and complex. All firms, however, try to develop a screening model (or set of models) that will allow them to make the best choices among alternatives within the usual constraints of time and money.

Souder (1972) identifies five important issues that managers should consider when evaluating screening models

1. **Realism** An effective model must reflect organizational objectives, including a firm's strategic goals and mission. Criteria must also be reasonable in light of such constraints on resources as money and personnel. Finally, the model must take into account both commercial risks and technical risks, including performance, cost, and time. That is Will the project work as intended? Can we keep to the original budget or is there a high potential for escalating costs? Is there a strong risk of significant schedule slippage?

2. **Capability** A model should be flexible enough to respond to changes in the conditions under which projects are carried out. For example, the model should allow the company to compare different types of projects (long-term versus short-term projects, projects of different technologies or capabilities, projects with different commercial objectives). It should be robust enough to accommodate new criteria and constraints, suggesting that the screening model must allow the company to use it as widely as possible in order to cover the greatest possible range of project types

3. **Flexibility** The model should be easily modified if trial applications require changes. It must, for example, allow for adjustments due to changes in exchange rates, tax laws, building codes, and so forth.

4. **Ease of Use** A model must be simple enough to be used by people in all areas of the organization, both those in specific project roles and those in related functional positions. Further, the screening model that is applied, the choices made for project selection, and the reasons for those choices should be clear and easily understood by organizational members. The model should also be timely It should generate the screening information rapidly, and people should be able to assimilate that information without any special training or skills.

5. **Cost** The screening model should be cost effective. A selection approach that is expensive to use in terms of either time or money is likely to have the worst possible effect causing organizational members to avoid using it because of the excessive cost of employing the screening model. The cost of obtaining selection information and generating optimal results should be low enough to encourage use of the models rather than diminish their applicability (Souder, 1994).

Let's add a sixth criterion for a successful selection model

Comparability It must be broad enough to be applied to multiple projects. If a model is too narrowly focused, it may be useless in comparing potential projects or foster biases toward some over others. A useful model must support general comparisons of project alternatives.

1. Following are the issues in project screening and selection
    a. Risk—Factors that reflect elements of unpredictability to the firm, including
    b. Technical risk—risks due to the development of new or untested technologies
    c. Financial risk—risks from the financial exposure caused by investing in the project

   d. Safety risk—risks to the well-being of users or developers of the project
   e. Quality risk—risks to the firm's goodwill or reputation due to the quality of the completed project
   f. Legal exposure—potential for lawsuits or legal obligation
2. Commercial—Factors that reflect the market potential of the project, including
   a. Expected return on investment
   b. Payback period
   c. Potential market share
   d. Long-term market dominance
   e. Initial cash outlay
   f. Ability to generate future business/new markets
3. Internal operating issues—Factors that refer to the impact of the project on internal operations of the firm, including
   a. Need to develop/train employees
   b. Change in workforce size or composition
   c. Change in physical environment
   d. Change in manufacturing or service operations resulting from the project
4. Additional factors
   a. Patent protection
   b. Impact on company's image
   c. Strategic fit

Project selection models come in two general classes numeric and nonnumeric. Numeric models seek to use numbers as inputs for the decision process involved in selecting projects. These values can be derived either objectively or subjectively; that is, we may employ objective, external values or subjective, internal values. The key is to remember that most selection processes for project screening involve a combination of subjective and objective data assessment and decision making.

Nonnumeric models, on the other hand, do not employ numbers at decision inputs, relying instead on other data.

Importance of Project Selection (Meredith and Mantel , 2012)

Before jumping into an examination of the two main methods of Project Selection as well as their various techniques, it's important to first understand just why Project Selection is so important for your business.

In addition to using the right project management methodology for your company, selecting the right projects can mean the difference between one year in the black or several in the red. An unreasonable project scope, loosely defined deliverables, and unrealistic goals can all lead to an enormous drain on your budget and critically damage productivity as well. But picking the right projects isn't as easy as just trusting your gut. Instead, selecting the right project for your company's skills and available resources requires a bit of pretty important calculation on your part. These calculations can be done in two different ways using the Benefit Measurement Methods or the Constrained Optimization Methods.

Benefit Measurement Methods

Benefit Measurement is a project selection technique based on the present value of estimated cash outflow and inflow. Cost benefits are calculated and then compared to other projects to make a decision.
The techniques that are used in Benefit Measurement are as follows (Meredith and Mantel , 2012)

Method #1 Benefit Measurement Methods

The Benefit Measurement Methods are likely going to be the only methods you'll be using directly as a project manager. While less complex than the Constrained Optimization Methods, they often don't require an advanced degree in finance to be able to understand them.

They're great for smaller projects that aren't especially complicated.

Benefit Measurement Methods, as the name suggests, rate potential projects according to a specific model and compare those results between the project candidates. Below are the most common Benefit Measurement Methods you'll be using as a PM.

1. Cost Benefit Ratio

The simplest of the Benefit Measurement Methods, the cost benefit ratio is an effective way of communicating the potential value of a project in easily understandable terms. It measures the costs of investing in a project against the value of the return once it is completed.

A project that requires Rs. 280,000 in resources to complete with an expected Rs. 420,000 returns would have a 46 (or 23) cost benefit ratio. Essentially, every Rs. 2 invested in this project would yield Rs. 3 in revenue. Projects with a lower cost benefit ratio (or a higher benefit cost ratio) should be selected if evaluated only by this method.

2. Economic Model

The Economic Model, also known as the Economic Value Added (EVA), is similar to the Cost Benefit Ratio technique in that it describes the difference between costs invested and revenue generated in one number – profit.

EVA defines as "net operating profit after tax – (invested capital X weighted average cost of capital)." This model provides a clear representation of the quantifiable benefits of a project once it's completed and can help give you a solid idea of what kinds of returns to expect for each project.

3. Payback Period

The Payback Period Technique takes a look at how long it will take your company to recoup its expenses with a particular project. If our Rs.280,000 project were to bring in Rs. 20,000 a year once it's completed, the total payback period would be 14 years.

It's worth remembering though, that any time you try to factor in returns over time you should be looking at the present dollar value of the future revenue as inflation and interest will all come into play.

4. Discounted Cash Flow (DCF)

The Discounted Cash Flow Analysis handles the problem of calculating the present value of future earned rupees. This is one of the best ways to calculate value of returns that occur over a long period of time rather than immediately after completion.

While the Payback Period Model is easy to calculate and simple to understand, the Discounted Cash Flow (DCF) model incorporates the time *value of money*. This concept helps translate future earnings into present day rupees values since a rupees in hand has more earning potential than one promised for later.

5. Net Present Value (NPV)

Using Discounted Cash Flow, the Net Present Value (NPV) model helps put the whole lifecycle of the project into perspective in terms of earnings.

For instance, calculating the earnings for year one of the project may return a net loss of, say, Rs 800. Year two may see a loss of Rs. 200, while years three, four, and five may result in gains of Rs.500, Rs.1000, and Rs.1500. All of these values would of course be informed by the DCF concept to translate future values into present dollars.

The Net Present Value of the project, then, would be the combination of all of these numbers (Rs.3000 minus losses of Rs.1000) and would equal Rs. 2000.

While there are a number of essential free tools at a project manager's disposal in general, the easiest one for calculating NPV is Excel by far.

The equation for determining Net Present Value according to Finance Formulas is

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + ... + \frac{C_T}{(1+r)^T}$$

$$\begin{aligned} &-C_0 = Initial\ Investment \\ &C = Cash\ Flow \\ &r = Discount\ Rate \\ &T = Time \end{aligned}$$

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + ... + \frac{C_T}{(1+r)^T}$$

$$\begin{aligned} &-C_0 = Initial\ Investment \\ &C = Cash\ Flow \\ &r = Discount\ Rate \\ &T = Time \end{aligned}$$

6. Scoring Models

Scoring Models may be the most flexible way of comparing projects to one another. Rather than focusing purely on financials, Scoring Models let you determine which qualities of a project are most important to you, your team, and your company at large.

You may, for example, choose to look at profitability, overall risk, support from stakeholders, and difficulty of the project.

Once the criteria are chosen, you'll want to weight them according to your priorities and rank each project in terms of these four measures using a consistent scale. The total numbers for a single project are then combined and used to reflect the project's total value, making it easy to compare your projects to one another.

7. Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) incorporates the Net Present Value into its calculation by setting the NPV to zero. Essentially, this means that all cash flow from a project (both negative and positive) even each other out.

Using the same equation as NPV where the NPV is set to zero, the IRR of a project is determined by solving for the variable "r" rather than NPV. If the Internal Rate of Return for a project is lower than the company's required rate of return (RRR), then that project can be eliminated entirely.

8. Opportunity Cost

The concept of opportunity cost is crucial to understand for any certified project manager worth their salt. Essentially, Opportunity Cost comes down to what you're missing out on by choosing one project over another.

More a supplemental technique than a standalone method itself, Opportunity Cost can be a great way to put a certain project choice into perspective. If, for example, Project 1 and Project 2 are worth Rs.75,000 and Rs. 85,000 respectively, going with Project 1 would have an opportunity cost of Rs.10,000 since that's how much your company would miss out on.

Method #2 Constrained Optimization Methods (Meredith and Mantel, 2012)

- While the Benefit Measurement Methods are generally the most widely used Project Selection methods for project managers, Constrained Optimization Methods may also come into play. These methods are great for larger, more complex projects where a number of intricate mathematical calculations will need to be performed.

- In fact, the Constrained Optimization Methods are also known as the Mathematical Model of Project Selection.
- Given their complexity though, many project managers will likely choose the Benefit Measurement methods to meet their Project Selection needs.

Following are the constrained optimization methods

1. **Linear Programming**

This programming method involves bringing down the cost of the project through reduction of the time required to complete it.

2. Nonlinear Programming

Nonlinear Programming aims at solving optimization problems within projects wherein some of the constraints or functions are nonlinear.

3. Integer Programming

This method focuses on integer values rather than fractional ones. Some products, like tables for example, can never be fractional.

4. Dynamic Programming

This method involves simplifying a complex problem by separating it into a number of simpler problems.

5. Multiple Objective Programming

The Multiple Objective Programming approach focuses on making a decision for a number of problems using mathematical optimization.

Developing a Project Network Plan (Passenheim Olaf, 2009)

A project network is the basis for scheduling budget, equipment, labour, communications, the estimated time consumption and the start and the finish dates. To structure a project network and define a standard which many people are able to use, the following terminology was defined for use in project networks. Figure 2.1 shows an example of a project network plan.

An activity is an element of the project network; activities are tasks which are defined to complete and to meet the goals of the project. An activity needs time to be completed. It has resources like personnel, budget, and space and, in most instances, relationships. An activity in a project network shows which tasks have to be performed in order to proceed, which resources are needed and how many of them. As the name implies, a parallel activity is a task which is processed at the same time, parallel to other tasks.

When using parallel activities, the consumption of resources will rise because they are required at the same time.

A merge activity is one activity which follows on more tasks; parallel activities come together in this activity. A succeeding activity can only be started when all preceding processes are ready.

An event is something which doesn’t consume project time; an event is generally a date. To define the start date or a date when something is delivered is an event. An event can also be the kick-off or the ending and many dates between.

A path is the connection between the depending activities. It has no duration and is the visualising of the relationship between the activities. The critical path is the shortest duration of the project. It is on this path that the most activities without buffer are placed and it is extremely important to know at which point on the critical path the project is because if an activity on the critical path is delayed, that delay will alter the total project duration.

The critical path is probably the most important outcome after drawing a project network plan. Every project has such a path and the workflow of all critical tasks sum up to the critical (shortest) duration time. All other tasks which are not on the critical path do not have an impact on the project. They could cause a delay which will have no impact on the finish , or in other words that delay would be highly unlikely to be so long as to affect the critical path. With the knowledge about the critical path the project team can act and react.

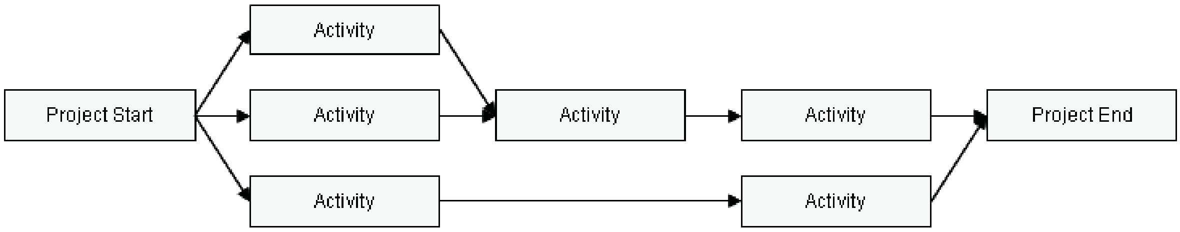

Figure 2.1 Example of a Project Network Plan

The following basic rules should be applied when developing a project network plan

- Networks flow typically from left to right. That is a must because only a common approach ensures that the project team knows how to read the network, developed out of the Western writing logic.
- An activity can only be used once it is not allowed to make loops, where an activity has to be fulfilled several times. If the same task has to be repeated, a new activity has to be drawn up. An activity cannot begin until all preceding connected activities have been completed. This is rather logical as it is not possible to begin something until the preceding tasks have been completed. This fact has to be shown in the network.
- Arrows on networks indicate precedence and flow; they can cross. To show the flow of the process and to show which tasks have to be done, arrows are used.
- Each activity has to have a unique identification number numbers help to support orientation in the network. The number of the activity shows the workflow. With numbering of activities it is easy to follow the path through a project. Normally the numbering of activities should be done in an ascending order, that means the start activity should have the lowest number and the last activity should have the highest number. Each activity needs a unique identification code; most computer programs accept numeric and alphabetic codes or a combination of the two. The planner or project manager should leave gaps between numbers (5, 10, 15 …), so he can add activities later. This is necessary because it's nearly impossible to draw a perfect project network from the beginning. Most times activities are forgotten or activities must be divided into smaller pieces. We showed that situation in the example above.

Project Scope Management (Passenheim Olaf, 2009)

Defining the project scope sets the stage for developing a project plan. Project scope is a precise explanation of the expected result of the project or product for the customer from an external as well as from an internal point of view in a specific, tangible, and measurable way. The scope should be developed under the joint direction of the project manager and customer. The project manager is responsible for an agreement with the customer on project objectives, deliverables at each stage of the project, technical requirements, etc. The project scope will be fixed in a document. Depending on its complexity it is stated in the project charter if it is at a manageable level, or in a special project scope statement frequently done on large projects. These documents are normally published and used by the customer and the other project participants for planning and measuring project success.

Scope describes what one expects to deliver to the customer when the project is complete. Due to the high priority of the project scope, a checklist including all elements of the project plan is a favorable way to ensure that scope definition is complete.

A project scope should contain the following elements

- Project objective
- Deliverables
- Milestones
- Technical requirements
- Limits and exclusions
- Reviews with customer

The project objective describes the project's outcomes intended and direct, short- and medium-term effects on the target group.

Deliverable is a tangible or intangible good or service produced as a result of a project that is intended to be delivered to a customer (either internal or external). A deliverable could be a report, a document, a software product, a server upgrade or any other building block of an overall project.

A milestone is a special event in a project that is reached at a point in time. The milestone schedule shows only major segments of work. It represents first, rough cut estimates of time, cost and resources for the project. The milestone schedule is built using the deliverables, as a platform to identify major segments of work and an end-date.

The technical requirements have to ensure the proper performance. For example, a technical requirement for a project with a university library could be that a student can be identified with his Computer IP-Address if he logs in into an internal database, to enable the university to track down any misuse. The importance of technical requirements is obvious because such a malfunction on a project could cause enormous damage.

The limits and exclusions should be well defined. Failure can lead to false expectations and to expending resources and time on the wrong problem. The completion of the scope checklist ends with a review with the customer, internal or external.

The objective is the common understanding and agreement of expectations. Is the customer getting what he or she desires in deliverables? Does the project definition identify key accomplishments, budgets, timing, and performance requirements? Are questions of limits and exclusions covered? Clear communication on all these issues is imperative to avoid claims or misunderstandings.

Setting clear project priorities, listed depending on their importance, also helps to avoid a scope creep. The management and/or the costumer define the order of priorities in accordance with their needs. Therefore the priorities can be set arbitrarily and vary from project to project. The three important factors for the success of a project are the meeting or exceeding of the expectations of the costumer and/or the management in terms of costs (budget), time (schedule) and performance (scope). The interrelationships among these criteria vary and can be seen as trade-offs between the project team and the customer. Fig. 2.2 illustrates this dilemma

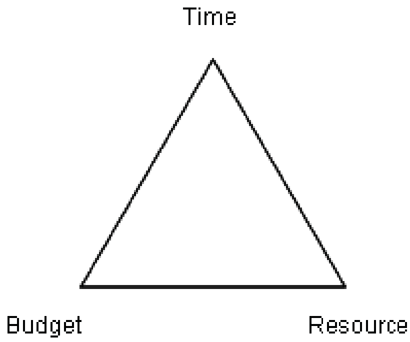

Fig. 2.2 Magic triangle

The trade-offs among time, costs and performance have to be allocated and managed by project managers. The trade-offs in a project occur between scope, cost and time. It should make clear that project managers have to balance these three points (regarding the magic triangle). If one of these objectives is missed, a project easily fails. In order to evaluate priorities there has to be a candid discussion between project managers, customers and upper management to establish the relative importance of each criterion. The work breakdown structure and the priority-matrix are tools which are used in practice to identify and define which criterion is constrained, which should be enhanced and which can be accepted.

The Work Breakdown Structure (Passenheim Olaf, 2009)

The Work Breakdown Structure (WBS) is a grouping of the work involved in a project oriented towards the deliverables that defines the total scope of the project. The WBS can be imagined as a roadmap of the project which breaks down the total work required for the project into separate tasks and helps group them into a logical hierarchy (see example Fig. 2.3). Different levels of detail assure the project managers that all products and work tasks are identified in order to integrate the project with the current organization and to establish a basis for control. Furthermore, the WBS organizes and divides the work into logical parts based on how the work will be performed. This is important as usually a lot of people are involved in a project and many different deliverables are set to reach one main objective to fulfill the project.

In addition to this, the WBS serves as a framework for tracking cost and work performance because every element which is defined and described in it can be estimated with reference to its costs and time needed. Consequently, the WBS enables the project managers to make a solid estimation of costs, time, and technical performance at all levels in the organization through all phases of the project life-cycle.

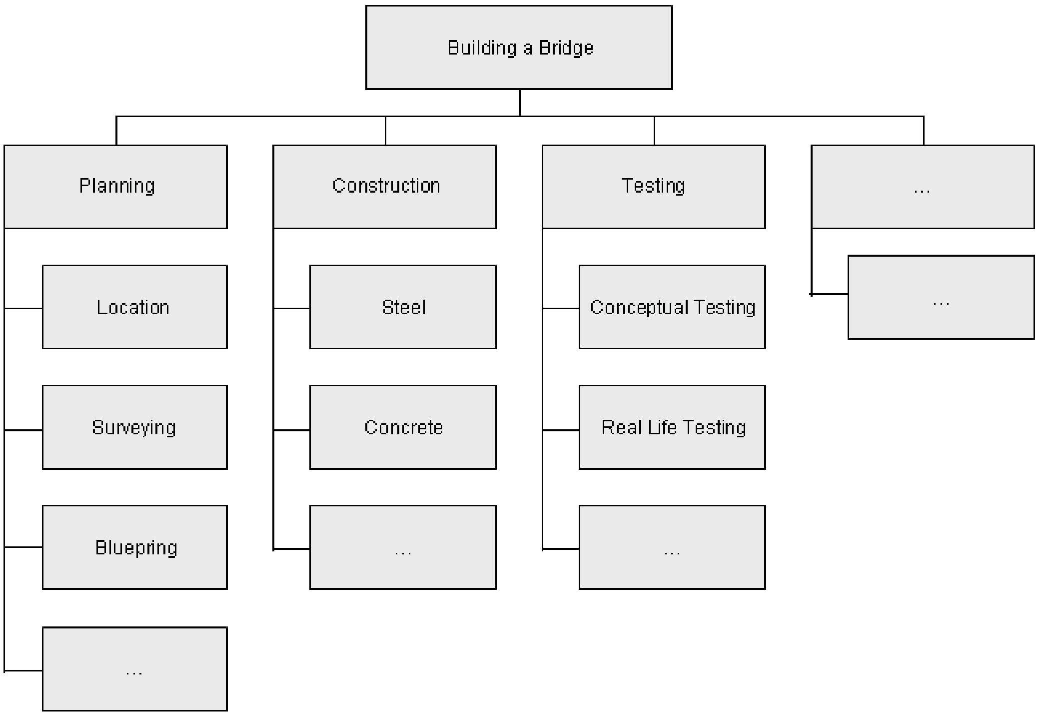

Fig.2.3 Work Breakdown Structure (Passenheim Olaf, 2009)

Decomposition is the key to success in creating a professional WBS. Decomposition describes the process of subdividing project deliverables into smaller, more compact and manageable components until the work and deliverables are defined at the work package level. This aforesaid work package is the lowest level in the WBS, and is the base at which the cost and schedule for the work can be estimated in a reliable way. The complexity of the project determines the level of detail for work packages.

To follow a hierarchical breakdown it is reasonable to start with the project as the final deliverable. Afterwards, the different deliverables can be decomposed into work packages. The decomposition to a lower level of detail enhances the ability to plan, manage and control the work. On the other hand, project managers have to be careful with the decomposition of sub-deliverables because an exaggerated decomposition can lead to non-productive management effort, inefficient use of resources, and decreased efficiency in performing the work. Therefore the project team has to find the balance of the level of detail during the planning process.

Project Charter Process (PMBOK Guide, 2013)

Develop Project Charter is the process of developing a document that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities. The key benefit of this process is a well-defined project start and project boundaries, creation of a formal record of the project, and a direct way for senior management to formally accept and commit to the project. The inputs, tools and techniques, and outputs for this process are shown in Fig. 2.4 depicts the data flow diagram of the process (Merla, 2010).

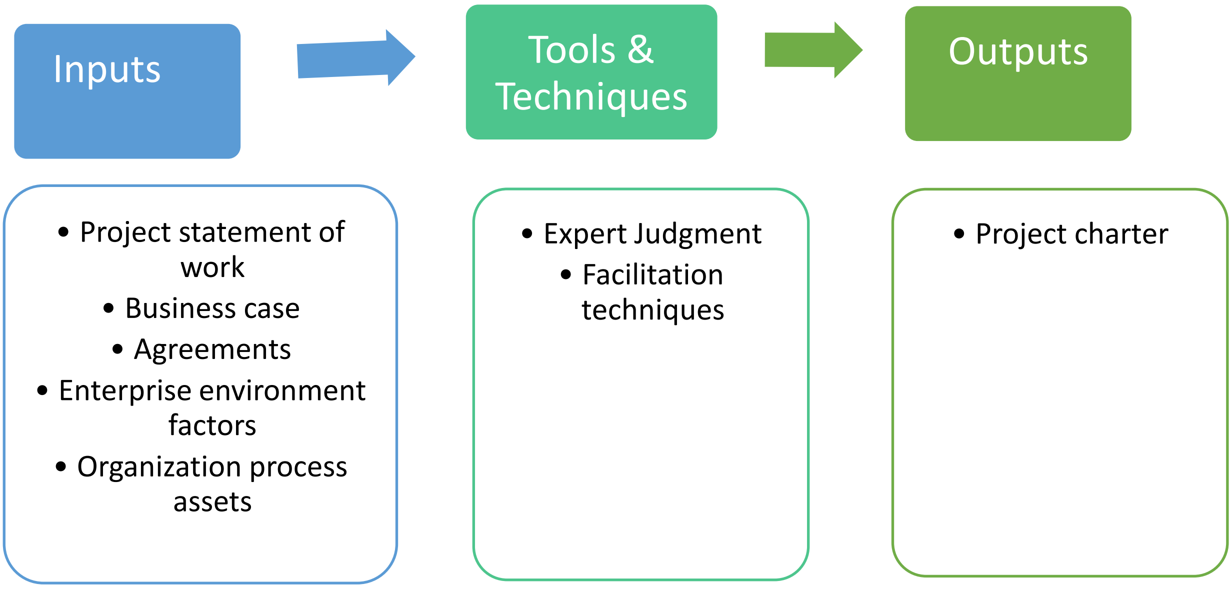

Fig 2.4 Project Charter Process

Develop Project Charter – Inputs, Tools & Techniques, Outputs In this lesson, we will review the inputs, tools and techniques, and outputs for the Develop Project Charter process. Remember that this process can be applied to start a project, a phase of a project or an iteration of a project.

Inputs

The inputs of the “Develop Project Charter” process include the following

- **Project Statement of Work** – the project statement of work identifies the products or services to be delivered by the project. For internal projects, if one has been developed, this would be provided by the project sponsor or initiator. For external projects, the statement of work is provided by the customer in a contract or other procurement document. In most cases, you would more likely have a statement of work for an external project than for an internal project.
- **Business Case** – the business case justifies the project and also usually comes from the initiator or sponsor of the project. In some organizations, the business case is developed concurrently with the project charter.
- **Contract** – a contract would be an input if the project is being performed for an external customer. Besides a statement of work, the contract would also provide conditions which may result in project team constraints.
- **Enterprise Environmental Factors** – generally, enterprise environmental factors are factors which may influence the execution of the process, limit the project team options or provide operational conditions or rules. In the case of the “Develop Project Charter” process, factors can include but are not limited to government regulations or standards, marketplace conditions, organizational structure, industry standards, and risk tolerances.
- **Organizational Process Assets** – generally, organizational process assets aid in the execution of the process. For the “Develop Project Charter” process, this could include templates,

Project Management procedures, organizational standards, processes and procedures, and historical information.

Tools and Techniques

The only tool or technique specified for the "Develop Project Charter" process is "Expert Judgment." Expert judgment can come from many sources such as Subject Matter Experts (SME's), consultants, other project managers, stakeholders, customers, and the Project Management Office.

Output

The only output of the "Develop Project Charter" process is the "Project Charter." The Project Charter provides a project vision or purpose along with supporting project objectives and high level requirements.

Possible components of the project charter include

- Project description
- High level risks
- Summary milestones (high level schedule)
- Summary budget
- Approval requirements
- Assigned project manager

Approval by the project sponsor the authorization or approval of the project charter is usually provided by someone external to the project team such as a project sponsor, a governing committee, or a project management office.

2.3 Project Resources and Scheduling (PMBOK Guide, 2013)

The schedule is a key part of project management. The schedule tells you when each activity should be done, what has already been completed, and the sequence in which things need to be finished.

Schedules

- They provide a basis for you to monitor and control project activities.
- They help you determine how best to allocate resources so you can achieve the project goal.
- They help you assess how time delays will impact the project.
- You can figure out where excess resources are available to allocate to other projects.
- They provide a basis to help you track project progress.

Project managers have a variety of tools to develop a project schedule – from the relatively simple process of action planning for small projects, to use of Gantt Charts and Network Analysis for large projects.

Schedule Inputs

You need several types of inputs to create a project schedule

- Personal and project calendars
- Description of project scope
- Project risks

- Lists of activities and resource requirements –
- Deadlines and resource availability

Scheduling Tools (Passenheim Olaf, 2009)

Here are some tools and techniques for combining these inputs to develop the schedule

- **Schedule Network Analysis** – This is a graphic representation of the project's activities, the time it takes to complete them, and the sequence in which they must be done. Project management software is typically used to create these analyses – Gantt charts and PERT Charts are common formats.
- **Critical Path Analysis** – This is the process of looking at all of the activities that must be completed, and calculating the 'best line' – or critical path – to take so that you'll complete the project in the minimum amount of time. The method calculates the earliest and latest possible start and finish times for project activities, and it estimates the dependencies among them to create a schedule of critical activities and dates.
- **Schedule Compression** – This tool helps shorten the total duration of a project by decreasing the time allotted for certain activities. It's done so that you can meet time constraints, and still keep the original scope of the project. You can use two methods here
- **Crashing** – This is where you assign more resources to an activity, thus decreasing the time it takes to complete it. This is based on the assumption that the time you save will offset the added resource costs.
- **Fast-Tracking** – This involves rearranging activities to allow more parallel work. This means that things you would normally do one after another are now done at the same time. However, do bear in mind that this approach increases the risk that you'll miss things, or fail to address changes.

Types of Project Constraints

Following are the projects constraints

1. **Technical or Logic Constraints** -related to the networked sequence in which project activities must occur.
2. **Physical Constraints Activities**- that cannot occur in parallel or are affected by contractual or environmental conditions.
3. **Resource Constraints**-The absence, shortage, or unique interrelationship and interaction characteristics of resources that require a particular sequencing of project activities
4. **Kinds of Resource Constraints** -People, materials, equipment

Resource smoothing (leveling)- Because demand resources will vary over the life of the project, it may be necessary to delay non-critical activities in order to even out resources.

When resources are not available to meet peak demands, the late start of some activities must be delayed and duration of the project increased. This is call resource-constrained scheduling.

Types of Resource Constraints

People Human resources are typically classified by the skills they bring to the project programmer, mechanical engineer, welder, inspector, etc. These many skills of human resources add to the complexity of scheduling projects.

Materials Chemicals for a scientific project, concrete for a road project, survey data for a marketing project. Material availability and shortages have been blamed for the delay of many projects.

Equipment Equipment is usually presented by type, size, and quantity and is often overlooked as a constraint. The most common mistake is assuming the resource pool is adequate for the project. Recognition of equipment constraints before the project begins can avoid high crashing or delay costs.

Classification of Scheduling Problems

- **Classification of Problem** - Using a priority matrix will help determine if the project is time or resource constrained.
- **Time-Constrained Project** - Must be completed by an imposed date. Time is fixed, resources are flexible additional resources are required to ensure project meets schedule.
- **Resource-Constrained Project** - Is one in which the level of resources available cannot be exceeded. Resources are fixed, time is flexible inadequate resources will delay the project.

Resource Allocation Methods

Limiting Assumptions

- Splitting activities is not allowed—once an activity is start, it is carried to completion.
- Level of resources used for an activity cannot be changed.

Risk Assumptions

- Activities with the most slack pose the least risk.
- Reduction of flexibility does not increase risk.
- The nature of an activity (easy, complex) doesn't increase risk.

2.4 Building Scheduling (Meredith and Mantel, 2012)

Following are the steps to build a schedule

1. Determine the tasks to be placed in the schedule
2. Determine the relationships among the tasks
3. Assign each task to specific staff
4. Estimate the amount of effort required for each task
5. Consider the other variables that go into building the schedule
6. Build a time reserve into the schedule for contingencies and unforeseen events
7. Identify the project's critical path
8. Check to see if staff is over-allocated
9. Repeat steps 3 and 5-8 until a baseline is established.
10. Place the schedule information in a Gantt chart

Resource Allocation Methods

Time-constrained projects Smoothing Resource Demand.

- This method focuses on resource utilization. It is difficult to manage a schedule when resource availability is erratic.

- Project managers typically resolve this by using resource leveling techniques that balance or smooth resource demand.
- Leveling basically delays non-critical activities using slack (float) to reduce peak demand.
- **Benefit** Peak resource demands are reduced, resources over the life of the project arereduced, and fluctuation in resource demand is minimized.

Resource Demand Leveling for Time-Constrained Projects

Advantages

1. Peak resource demands are reduced.
2. Resources over the life of the project are reduced.
3. Fluctuation in resource demand is minimized.

Disadvantages

1. Loss of flexibility that occurs from reducing slack, in this case, eliminating the slack on “fence & walls” activity.
2. Increases the criticality of more activities. With “fence & walls” having no slack and this project being time sensitive, nothing could go wrong or else the project would suffer a delay.
    - Resource Allocation Methods
    - Resource-Constrained Projects
    - Resources are limited in quantity and availability

Activities are scheduled using heuristics (or rule-of-thumb) that focuses on activities having

1. Minimum slack
2. The smallest or least duration
3. The lowest activity ID number

Heuristics is applied by using the parallel method an iterative process starting with the first time period and scheduling the start of activities period-by-period by using the 3 priority rules

1. Impacts of Resource-Constrained Scheduling
2. Usually reduces project slack and thereby reduces flexibility
3. Increases the number of critical and near-critical activities.

Scheduling complexity increases because resource constraints are now added to the normal technical constraints of managing the project and flow of activities. The critical path is no longer meaningful. Resource constraints can break the sequence and leave the network with a set of disjointed critical activities.

Benefits of Scheduling Resources

- If a project is truly dealing with limited or scarce resources, the schedule will end up being a resource-constrained schedule, not time-constrained.
- Schedule should be created before the project begins. This allows time to consider other reasonable alternatives such as Cost-Time tradeoffs and Changes in Priorities.
- Resource scheduling also provides information for time-phased work package budgets in order to assess the impact of unforeseen events as well as the amount of flexibility in available resources.

2.5 Project Planning Tools (Passenheim Olaf, 2009)

Project management involves understanding a wide variety of topics—from people management to strategy, number crunching to IT to communications. All these disparate aspects of a business come with their own tools. In this article, we'll take a look at some of the most important items in a project manager's planning toolkit to help plan, monitor progress, identifying critical paths, and other tasks required for a project to run smoothly.

Network Diagrams

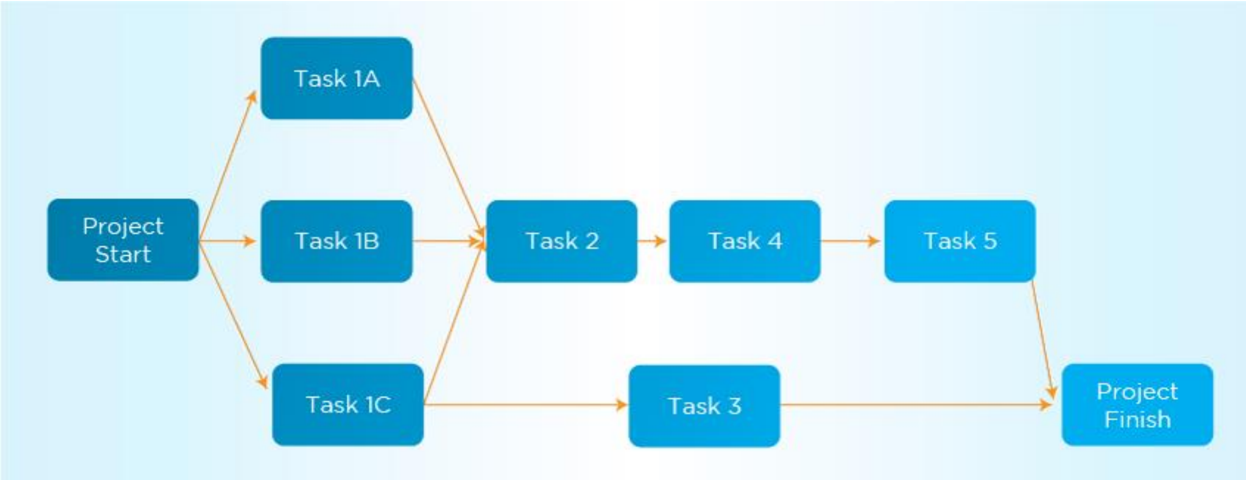

Fig. 2.5 Network analysis (SourcePassenheim Olaf, 2009)

Network diagrams are one of the project management tools a project manager uses for project planning. It is also sometimes referred to as an "Arrow" diagram because it uses arrows to connect activities and represent precedence and interdependencies between activities of a project.

There are some assumptions that need to be made while forming the Network Diagram. The first assumption is that before a new activity begins, all pending activities should have been completed. The second assumption is that all arrows indicate logical precedence. This means that the direction of the arrow represents the sequence that activities need to follow. The last assumption is that a network diagram must start from a single event and end with a single event. There cannot be multiple start and end points to the network diagram.

In order for the network diagram to calculate the total duration of the project, the project manager needs to define four dates for each task. The first two dates relate to the date by when the task can be started. The first date is Early Start—this is the earliest date task can be started. The second date is Late Start—this is the last date the task should start.

The second two dates relate to the dates when the task is complete. Early Finish is the earliest date by when the task can be completed, while Late Finish is the last date by when the task should be completed. The Duration of the task is calculated as the difference between the Early Start and Early Finish of the task. The difference between the Early Start and Late Start of the task is called the Slack time available for the task. Slack can also be calculated as the difference between the Early Finish and Late Finish dates of the task. Slack time for a task is the amount of time the task can be delayed before it causes a delay in the overall project timeline.

Path Method

Critical Path method, or CPM, is an important project planning tool used by project managers to monitor the progress of the project to ensure that the project is on schedule. The Critical Path for a project is the longest sequence of activities on the network diagram and is characterized by zero Slack for all activities on the sequence. This means that a smallest delay in any of the activities on the critical path will cause a delay in the overall timeline of the project.

This makes it very important for the project manager to closely monitor the activities on the critical path and ensure that the activities go smoothly. If needed, the project manager can divert resources from other activities that are not on the critical path to activities on the critical path to ensure that the project is not delayed. When a project manager removes resources from such activities, he needs to ensure that the activity does not become a critical path activity because of the reduced number of resources.

The Program Evaluation and Review Technique (PERT) (Passenheim Olaf, 2009)

The Program Evaluation and Review Technique is a network analysis technique which uses the AOA or AON approach to estimate project duration. PERT has the ability to deal with uncertainty in activity completion times. It can help to develop more realistic schedules to reduce cost and time requirements. This is a great advantage compared to the critical path method. The CPM is more deterministic and uses fixed time estimates for each activity. Time variations, that can have a great impact on the completion time of a complex project, will not be considered. For the performing of PERT estimates, a three-point estimate for each activity is required. A three-point estimate is an activity duration estimate that includes an optimistic, most likely and pessimistic estimate. The optimistic estimate is based on a best-case scenario. Generally, it is the shortest time in which the activity can be completed. The most likely estimate is based on an expected scenario. The completion time has the highest probability. The pessimistic estimate is based on a worst-case scenario. That is the longest time that an activity might require.

To use PERT, the weighted average for the duration estimate of each project activity has to be calculated by using the following formula

$$\text{PERT weighted average} = \frac{\text{optimistic time} + 4^{*}\ \text{most likely time} + \text{pessimistic time}}{6}$$

Fig 2.5 PERT Formula

Often, only a discrete estimate, for example the most likely estimate, is used to estimate activity durations. If now the PERT should be used to determine a project schedule, numbers for the optimistic, most likely and pessimistic duration estimates for each project activity have to be collected. For example, the duration of two days is estimated for an activity, it would be the most likely time. Now, an optimistic time has to be estimated. In this case it could be one day and the pessimistic estimate could be nine days. Without using PERT, the duration will be fixed at two days. After collecting the numbers, the PERT weighted average can be calculated

$$\text{PERT weighted average} = \frac{1 \text{ day} + 4 * 2 \text{ days} + 9 \text{ days}}{6} = 3 \text{ days}$$

Fig 2.6 PERT Example

With this example, the difference between PERT and the critical path will be clarified. The duration of the activity is fixed at two days with the critical path method. But with the PERT method the duration of three days is determined. This is a good example to show that PERT has the ability to deal with uncertainty in activity completion times.

The main advantage of PERT is that it attempts to address the risk associated with duration estimates. The disadvantages of this method are that several duration estimates are required and the method is not the best one for assessing risks.

Gantt Charts (Passenheim Olaf, 2009)

Gantt charts (bar charts) like those used in modern project management software and control charts are the typical tools used for communicating project schedule status. The Gantt chart is the most favored, used and understood. This kind of chart is commonly referred to as a tracking Gantt chart. Gantt and control charts serve well as a method for tracking and trending schedule performance. Their easy-to-understand visual formats make them the favored tools for communicating project schedule status – especially to top management, who do not usually have time for details. Adding actual and revised time estimates to the Gantt chart gives a quick overview of project status on the report date. Figure2.7 presents a baseline Gantt chart and a tracking Gantt chart for a project. The solid bar below the original schedule bar represents the actual start and finish times for completed activities or any portion of any activity completed.

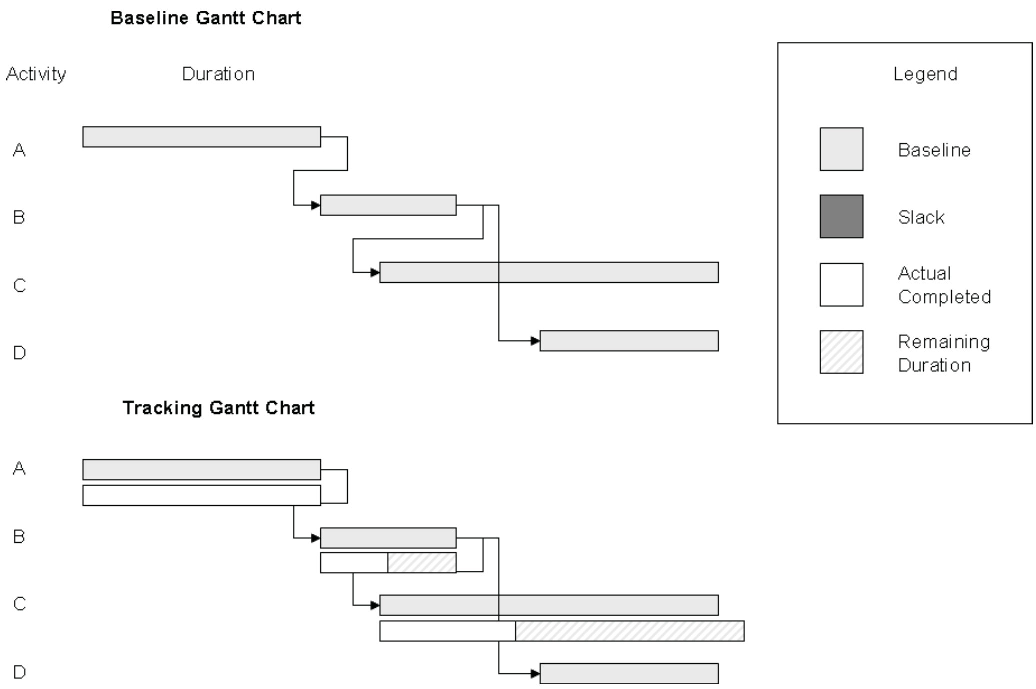

Fig. 2.7 Gantt chart (Passenheim Olaf, 2009)

A control chart is another tool used to monitor past project schedule performance and current performance and to estimate future schedule trends. The chart is used to plot the difference between the scheduled times on the critical path at the report date with the actual point on the critical path. Control charts are also frequently used to monitor progress toward milestones. As a result of the performance tracking either via a Gantt chart or a control chart, a progress report has to be written and distributed.

Bar Chart [Tool]

A bar chart is a graphical tool that can be used to present data in a way that is easy to read, easy to understand, and provides the ability for easy comparison of all provided data. It can be used to provide the project team and all of those looking for project related information data from the individual schedule activities and work breakdown structure components. In a typical bar chart (also referred to as a bar graph or a Gantt chart, named after H. L. Gantt who published one of the first recorded bar charts in 1931), the left side of the chart displays the work breakdown structure components or the individual schedule activities, the dates in question are placed along the top of the chart, and the activity durations are represented by date-placed horizontal bars. These bars can be color coded if necessary, or they can be filled in with patterns to allow for more cost-effective printing in grayscale.

The Logical Frame Approach

The Logical Framework Approach (LFA) is a highly effective strategic planning and project management methodology with wide application. It is particularly valuable for water management and sanitation projects, especially because water — the resource base — has diverse and competing uses. It comprises an integrated package of tools for analyzing and solving planning problems and for designing and managing their solutions (the approach). The product of this analytical approach is the log frame (the matrix), which summarizes what the project intends to do and how, what the key assumptions are, and how outputs and outcomes will be monitored and evaluated.

Summary

The project plan is the "visualization" of the work breakdown structures. All information gathered so far is combined and links and dependencies between individual tasks are visible. Project times can be tracked and, most important, critical activities in terms of times and resources can be planned, rehearsed and optimized. The critical path is the most important outcome of a project plan. It is important to understand the critical path to know where you have critical activities and where you do not. There might be a lot of activities that end up running late, but the overall project will still complete on time since the late activities are off the critical path.

Project selection techniques help you to select a project which could provide you with a better return on investment and recognition. There are various methods to select a project; however, if the project is small and not very complex, you will go for the benefits measurement model. You will go for the constrained optimization method if it is a large and complex project.

Chapter 3- Project Development

Objective

- To understand project selection techniques
- To understand Project charter process
- To understand various planning tools

Structure

3.1 Project Execution

3.2 Monitoring through Information Systems

3.3 Capital Cost Estimating, Monitoring Techniques and time control System

3.4 Project Procurement and Materials Management

3.5 Pre-Feasibility Study

3.6 Feasibility Studies and Project Break-even point

To Do Activities

1. Discuss benefits of timely, appropriate and detailed information. How value can be assigned to these characteristics.
2. What are the advantages for Project management of having computerized system over manual one? Explain disadvantages.
3. How should project management information system should be chosen?
4. Discuss the uses of project management information system in different stages of project life cycle.
5. How would a project management information system differ from an ordinary management information system?
6. Visit a company and make a report on its material management, project break even analysis.
7. Make a survey a report of any one orgnaisation nearby to study its monitoring information system

3.1 Project Execution

Project development is the process and the facility of planning, organizing, coordinating, and controlling the resources to accomplish specific goals. The process takes a transportation improvement from concept through construction (Phillips, 2003).

A successful implementation of project development can be separated into 5 project development phases (Fig. 3.1)

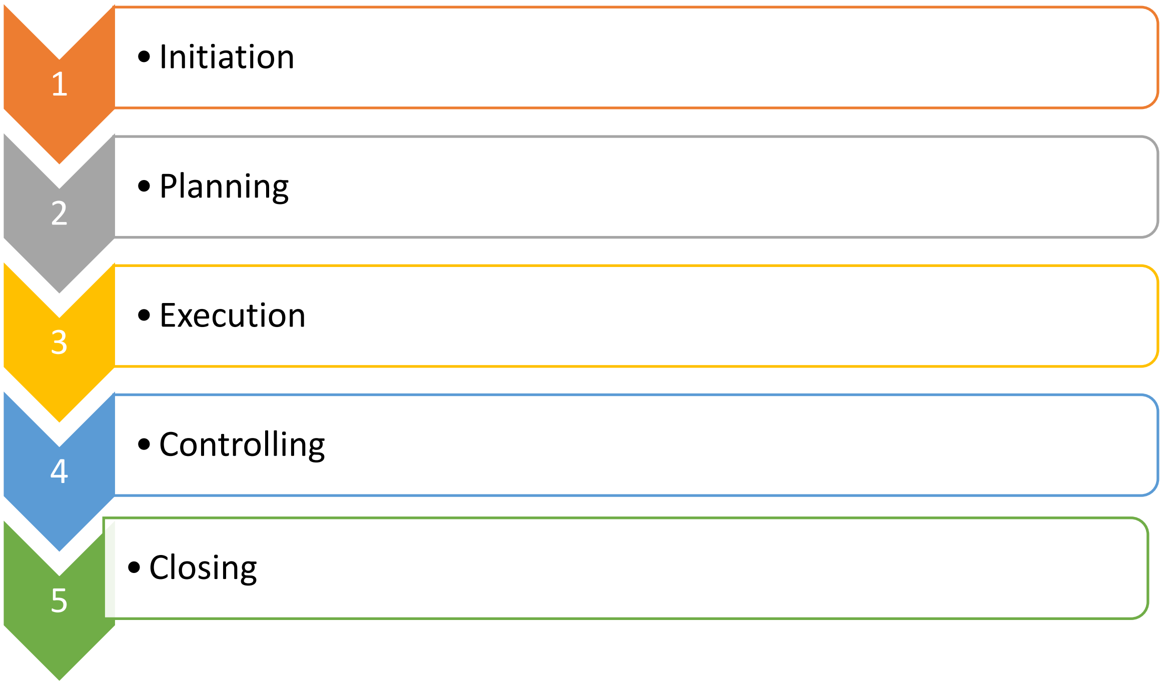

Fig. 3.1 Phases of Project Development (Phillips, 2003).

Initiating

The first part of developing a successful project is to make sure that you are entirely sure of everything that needs to be done and that you have a clear objective and title for your project- after all, how can it be successful if you don't know exactly what the desired outcome is?

Planning

This is probably the most important part of the whole process. organizing what will be done. It needs to be detailed and well thought out to ensure that nothing is missed, carrying out risk assessments and making sure that everyone has what they need to be able to do the tasks that are required of them.

It is at this stage when you should look at detailed and realistic costing, timelines, risk analysis, resourcing and communication systems

Execution

Now you have your project properly planned, you can start executing it. Make sure that you stick to your plan as closely as possible, and have a communication hub where stakeholders can collaborate on progress — like project management software. But it is also recommended that you continually review its progress and make any changes or adaptations as you go.

Control

Control needs to be carried out during the execution stage. This is where you need to try to ensure that the plan is kept to as closely as possible and that you are regularly monitoring it to ensure that the project doesn't spin out of control.

Closing

Once that the project is finished, it is recommended that you write a closing report, giving a summary of the project, how well you managed to keep to the plan, any changes that you had to make and why, and what you would do differently if you were to carry it out again. This is helpful for the future planning of projects and helping to make the next one even more successful.

The key to completing a successful project is all about the planning, and any help that you can get in this process can make all of the difference (Phillips, 2003).

Project Execution

Tasks completed during the Execution Phase include

- Develop team- Once you've clearly defined the scope of the project, identifying the talents needed to execute your vision becomes easier. Carefully select the individuals who will make up your team, and delegate tasks and activities to people best suited for each. Proper task delegation can come off as a show of confidence in your team members' inherent abilities, which then boosts morale and becomes instrumental in bringing about the best possible project results.
- Assign resources- It is preparation of a list of task to be completed and assigning recourse in front of that task. Following is example for preparation of resource assignment.

Sr. No.	Task	Duration	Resource type
1			
2			

There are two types of resource plans. One is hypothetical, based on resource type set without any resource constraints. Resource type refers to the skill set that a task requires for completion.

The other is an actual resource plan, based on actual resource availability. A hypothetical schedule based only on the resource types needed produces a hypothetical resource plan.

Execute project management plans (Fig. 3.2) The whole point of a project is to produce deliverables of some sort and the execution phase is where this happens. Essentially, work is done according to the project plan and that work is monitored and the results fed back to the people responsible for the plan so that it can be updated to reflect the progress made. It is possible to see this phase of the project as consisting of two processes the 'doing' or executing, and the monitoring and controlling (Phillips, 2003).

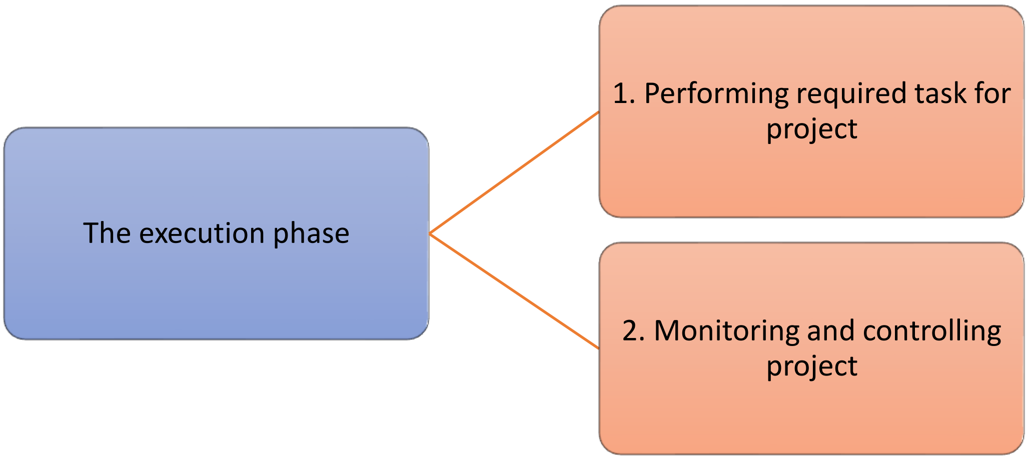

Fig. 3.2 Execution phase (Source Phillips, 2003)

The actions performed during this process include

- Performing the activities needed to meet the project objectives
- Obtaining and manage quotations, bids and proposals as needed
- Managing the project team and manage other resources
- Collecting and analyze performance data
- Generating project data for status reports and forecasts
- Managing risks
- Conducting change control and implementing approved changes
- Collecting and documenting lessons learned

Procurement Management

Procurement management is known to help an organization to save much of the money spent when purchasing goods and services from outside. It also has several other advantages (Cleland &Gareis, 2006). It involves following steps

1. Checking which goods and services need to be purchased from outside.
2. Consider various options and alternatives instead of purchase
3. The next step typically would be to call for bids. During this stage, the different suppliers will provide you with quotes. Then making comparative of quotations and deciding which supplier is has minimum bid cost with required quality.

PM directs and manages project executionThe project team does this by executing the work packages and creating the products that are contained within them (Cleland &Gareis, 2006). There are four inputs to Direct and manage project execution

1. The project management plan.

-This process is focused on the executing the contents of the project plan and this are therefore the most important inputs for this process.

2. Approved change requests.

As a natural consequence of performing work changes while performing Direct and management project execution, will normally be requested and such changes maybe as a result of any part of the project as may be the impact of such requested changes. All requested changes are brought into the process of perform integrated change control where they are evaluated for their impact on the whole of the project.

Such change requests may be approved or rejected, and those that are approved will often modify the contents of the project management plan and its components such as cost, schedule and the scope baselines (Cleland &Gareis, 2006).

The term 'change request' refers to one of many situations

Change Request
These are requests that may change budgets or schedules, increase or reduce the project scope, or modified in some way the various plans, procedures processes or policies relating to the project while carrying out Direct and management project execution

Corrective Action
Such a request is there to bring about a change to future results or performance of the project work so that they remains aligned with the project management plan.

Preventative Action
As the name suggests this type of change takes proactive action to avoid the occurrence of a problem. This may be to reduce the probability or impact of a risk, to increase the chance of opportunity, or to reduce the impact of a current issue.

Defect
These arise as a result of identifying a defect in a project deliverable or component. They are an imperfection or deficiency such that the product or component does not meet its requirements all specifications and hence will need to be repaired or replaced.

The recommendation therefore of a defect, is either to repair or replace it. This occurs during Direct and management project execution (PMPA, Guide, 2013).

3. Enterprise Environmental Factors.

Since the direct and manage project execution process covers everything that the project is to produce or create, then so too will be the range of possible enterprise environmental factors that may need to be considered in the Direct and management project execution process. These will range from soft aspects such as your organizations values and work ethic, the structure and culture of your organization, and its appetite for risk taking (PMPA, Guide, 2013).

At the other end of the scale, factors to be considered may include laws and regulations, the physical or operational environment within which the project is taking place, the socio economic impact that the project may have.

4. Organizational Process Assets.

Since this is an execution process, then such assets will be focused on aiding the creation of the projects products and deliverables. Examples may be historical data for previous project plans, tools and techniques along with organizational competences, lessons learned from previous similar projects along with their estimating data, and any databases of project information and knowledge (PMPA, Guide, 2013).

Set up Tracking Systems Project tracking software is widely used to create project plans, execute reports and use timesheets. The project tracking software handles time and tasks efficiently and helps you to keep track of your budget. It also reflects how many project phases have been completed till date plus how many project tasks are still left to be completed.

Following are some key considerations and features for selecting project management platform (PMPA, Guide, 2013)

- Collaborate with team member in real-time – Project management applications offer communication tools to help teams discuss tasks in real time. The solution can keep each team member updated and enable them to quickly deal with problems as they arise.
- Document sharing – The software offers document sharing tools to enable users to edit and update project reports, and create systems for communication and transparency.
- Manage project costs – Project management software generally offers tools that help to manage project costs.
- Manage risks, budgets, and forecasting – The software helps you to identify project risks, track budgets, and create forecasts.
- Reporting capabilities – The system offers flexible report formats and helps you access the required data quickly and easily to keep projects on schedule.
- Intuitive to use – Dashboard-based software is easy to install and simple to learn and use. This means faster implementation and ramp-up times.

Status Meetings

Status meetings are tools for the project manager for monitoring the project, for developing his team, and for identifying key critical areas of project progress (Brownlee, 2008). Status meetings equalize the pressure between all members of the project team by allowing each member to share the burden of other team members.

Update Project Schedule schedule updating is basically the task project managers carry out that relates to updating the project schedule. It involves

- Updating the project management software with actual work completed
- Recording new estimates in the software
- Updating the state of play with resources, for example adding in any holidays that a project team member is taking so that you can accurately schedule their work
- Entering other data into the project management software that enables the project manager to track progress and monitor the work.

Modify project plans as needed A change management plan defines activities and roles to manage and control changes during the execution and control stage of the project (Brownlee, 2008). Change is measured against the project baseline, which is a detailed description of the project's scope, budget, schedule, and plans to manage quality, risk, issues, and change. During the execution and control stage, changes may require one or more revised project baselines to be issued (Brownlee, 2008).

Change can occur throughout the project life cycle. A Change Management Plan helps control the effect of changes during the execution and control stage, thereby avoiding overruns in cost and schedule, incoherent scope, poor quality, etc. The Change Management Plan is critical to the success of the project. There should be no change without evaluation and approval.

3.2 Monitoring through Information System

The project management information system (PMIS) is used to plan schedules, budget and execute work to be accomplished in project management (Bakens, 2011).

Project Management Information System (PMIS) are system tools and techniques used in project management to deliver information. Project managers use the techniques and tools to collect, combine and distribute information through electronic and manual means. Project Management Information System (PMIS) is used by upper and lower management to communicate with each other (Bakens, 2011).

Project Management Information System (PMIS) help plan, execute and close project management goals. During the planning process, project managers use PMIS for budget framework such as estimating costs. The Project Management Information System is also used to create a specific schedule and define the scope baseline. At the execution of the project management goals, the project management team collects information into one database (Bakens, 2011).

PMIS is used to compare the baseline with the actual accomplishment of each activity, manage materials, collect financial data, and keep a record for reporting purposes. During the close of the project, the Project Management Information System is used to review the goals to check if the tasks were accomplished. Then, it is used to create a final report of the project close.

The PMIS should enable a project team to pinpoint the variances in terms of time, money and resources and see if they can find the reason why these have occurred. It should enable the team to track the status of each part of the project and assess the work that is completed and the work that remains to be done (Bakens, 2011).

When this information is available the project team will be able to reallocate the necessary resources to see that each part of the project contributes to the success of the project. It should be able to help the project leaders to assess the impact on the project from any future risks caused by time and cost overruns, and also to ensure that the quality of the project does not suffer. It should help the team to understand which of the parts of the project require revised guidelines and how they are to be implemented

Project Control

Project management is a complex process it involves large parameters to consider to complete a project. There are lots of project management methodologies in modern software development industry. Their selection depends on the software development method you use in your project (Globerson & Zwikeal 2002).

Most developers agree that the process of project management is subdivided into three stages.

1. **Project planning** There is no software development project in the world that can be realized without a plan. Plans are necessary to forecast the terms of product delivery and to define all activities of the team for the period of project realization. In some methodologies plans can change during the process of software development. Other methods do not provide such ability.
2. **Project management** It is called project monitoring. Project execution is monitored

constantly during this process. The monitoring activities are required to make sure that the initial plan of the project is implemented properly. The main goal of project monitoring is to detect problems in project realization. Such problems may lead to project failure. That is why they should be eliminated.

3. **Project control** It is aimed at defining the sources of problems in plan implementation and removing them. During the control stage the developers usually conduct product testing. It is required to make sure that problems in plan implementation didn't lead to defects in the final

Project Controls is a function that is critical to achieving successful project and programme outcomes i.e. delivering required benefits to cost, time and performance. Project Controls are the data gathering, data management and analytical processes used to predict, understand and constructively influence the time and cost outcomes of a project or programme; through the communication of information in formats that assist effective management and decision making(Globerson & Zwikeal 2002).

Process control- It is the tools, process, people skills, experiences when integrated with right information at right time to enable right decisions to be made.

This definition covers all stages of a project lifecycle from initiating and scoping the project through to closure, final learning from experience and analytical analysis of overall project performance.

Project Control professionals sit within the Project Team, work for, and are responsible to the Project Manager. They are the heart of the Project Team. If Project Management is concerned with making informed and accountable decisions project controls is about "informing, monitoring and analyzing" – to exercise control it is necessary to be aware.

Project Control professionals generate and maintain the information that brings awareness to the Project Manager and senior Managers so that control can be exercised.

Components of Project Control

Depending upon how Project Controls is viewed will influence what is considered as the component parts of the function (Shtub, Bard &Globerson 2005). On this basis the component elements of Project Controls are to do with measuring and monitoring controlling variables, these are principally time and cost aspects

- Planning and Scheduling
- Risk Management (includes identification & assessment)
- Cost estimating and management
- Scope and Change Management
- Earned Value Management
- Document Control
- Supplier Performance
- Maintaining the project baseline
- Reporting

Importance of Project control

The successful performance of a project depends on appropriate planning. The PMBOK Guide defines the use of 21 processes that relate to planning out of the 39 processes for project management, (Globerson & Zwikeal 2002). The execution of a project is based on a robust project plan and can only be achieved through an effective schedule control methodology. The development of a suitable Project Control system is an important part of the project management effort (Shtub, Bard &Globerson 2005). Furthermore, it is widely recognized that planning and monitoring plays a major role as the cause of project failures. Despite the continuous evolution in the project management field, it appears evident that the traditional approach still shows a lack of utilisation of Project Controls and there have been a number of articles published to support the importance of control in the achievement of project objectives.

Scope Creep

Scope creep (also called requirement creep, or kitchen sink syndrome) in project management refers to changes, continuous or uncontrolled growth in a project's scope, at any point after the project begins (Lewis & James, 2002).

This can occur when the scope of a project is not properly defined, documented, or controlled. It is generally considered harmful (Kendrick&Tom, 2015).

It is related to but distinct from feature creep, because feature creep refers to features and project creep refers to the whole project.

Scope creep can be a result of

- poor change control
- lack of proper initial identification of what is required to bring about the project objectives
- weak project manager or executive sponsor
- poor communication between parties
- lack of initial product versatility

Scope creep is a risk in most projects. Most megaprojects fall victim to scope creep ((Kendrick&Tom, 2015). Scope creep often results in cost overrun. A "value for free" strategy is difficult to counteract and remains a difficult challenge for even the most experienced project managers (PMPA, Guide, 2013).

Causes of Scope Creep

1. Lack of clarity and depth to the original specification document.
2. Allowing direct [unmanaged] contact between client and team participants.
3. Customers trying to get extra work without extra money.
4. Beginning design and development of project before a thorough requirement analysis and cost-benefit analysis.
5. It may be due to lack of foresight and planning.
6. Poorly defined initial requirements.
7. Management gives extra promises, and put burden on the developers to give deliver project in tight time frames.

Solutions for Scope Creep

1. Involving sponsors in the scope planning process
2. A poorly defined scope is one of the leading causes of scope creep.

One way to avoid this is to involve sponsors early in the scope planning process. Instead of defining the scope based completely on your interpretation, get sponsors to offer their recommendations as well (PMPA, Guide, 2013).

1. Here are two ways you can do this

I. Ask sponsors to create their own project charter that includes the project vision *and* their business need. The overlap between this charter and yours would give you the project scope.

II. Ask sponsors to define all high-level features that are *not* in scope. Knowing what you don't have to do is often more helpful than knowing what to do.

2. Define the scope based on the work breakdown structure (WBS)

As we saw earlier, the scope statement and project charter are inadequate for defining project scope. They only give you a high-level overview of the requirements, not an actual list of deliverables.

Solve this problem by defining the scope based on the WBS.

Here's how

I. Create a project charter based on your interpretation of the client's needs

II. Distill the project charter into a scope statement

III. Decompose the high-level objectives in the scope statement into a list of deliverables

IV. The goal should be to find the specific things you need to create for the project to be a success. If the sponsor requests something that is *not* in the WBS, it is likely out of scope.

3. Create a change management plan

The change management plan defines how you record, track, and act on change requests. Without it, you risk losing track of changes and stretching the project beyond scope.

An effective change management plan needs the following

1. A centralized and easily accessible library of all requested changes and their current status.
2. A way to evaluate the priority of each change request based on its business/project impact, requesting stakeholder, and urgency.
3. A process to evaluate how the change will affect the project's outcome, any dependent tasks, and existing schedules and budgets.
4. A way to track actions taken in response to change request.
5. A process to communicate any issues related to the change request (and who to communicate them with).
6. While a spreadsheet can suffice, you'll see much better results by using project management software.

3.3 Capital Cost Estimating

Total project cost is defined as all costs specific to a project incurred through startup of a facility, but prior to the operation of the facility (Meredith & Mantel, 2012). Total project cost is addition of total estimated cost (TEC) and other project costs (OPC).

Total Estimated Cost TEC is defined as all engineering design costs (after conceptual design), facility construction costs, and other costs specifically related to those construction efforts. These are typically capitalized. TEC will include, but not be limited to project and construction management during Titles I, II, and III; design and construction management and reporting during design construction; contingency and economic escalation for TEC-applied elements; ED&I during Titles I, II, and III; contractor support directly related to design and construction; and equipment and refurbishing equipment.

TEC is divided into costs associated with ED&I, project management (PM), construction management (CM), and construction contractors (CC).

a. Engineering Design and Inspection ED&I activities include the engineering and design activities along with the inspection activities.
b. Project management Project management covers those services provided on a specific project, beginning at the start of design and continuing through the completion of construction, for planning, organizing, directing, controlling, and reporting on the status of the project.
c. Construction management Construction management covers those services provided by the organization responsible for management of the construction effort during design, and continuing through the completion of construction.
d. Construction contractors Construction contractors cover salaries, travel, and other expenses of engineers, engineering assistants, and their secretarial support responsible for engineering and design performed by the construction contractor.

Other Project Costs OPCs are defined as all other costs related to a project that are not included in the TEC, such as supporting research and development, pre-authorization costs prior to start of Title I design, plant support costs during construction, activation, and startup. OPCs will include, but not be limited to research and development; NEPA documentation; project data sheets (PDSs); CDR; short form project data sheets; surveying for siting; conceptual design plan; and evaluation of RCRA/EPA/State permit requirements.

Total Project Cost TPC is defined as all costs specific to a project incurred through the startup of a facility but prior to the operation of a facility. It is comprised of TEC and OPC. TPC will include, but not be limited to, activities such as design and construction; contingency; economic escalation; feasibility study reports (FSRs); maintenance procedures (to support facility startup); one-time start-up costs, initial operator training, and commissioning costs; and operating procedures (to support facility start-up).

Monitoring Techniques and Time Control System

The Monitoring and Controlling process oversees all the tasks and metrics necessary to ensure that the approved and authorized project is within scope, on time, and on budget so that the project proceed with minimal risk (PMPA, Guide, 2013). This process involves comparing actual performance with planned performance and taking corrective action to yield the desired outcome when significant differences exist. Monitoring and Controlling process is continuously performed throughout the life of the project (Meredith & Mantel, 2012).

The monitoring function is composed of two activities

1. Data collection

2. Information reporting

Data for monitoring the project must be directly related to the project- it's plans, outputs, schedules, budget, and Standards. This collected data must be reported to the management frequently- daily, weekly or monthly. The function of reporting data to management is to control problems when they are still small (Meredith & Mantel, 2012).

- Evaluation and comparison of actual measured results against those planned is the fundamental principle of project monitoring process.
- Whenever there is a variance, corrective action is required to keep the project on schedule and to budget.
- The inputs are the project plan and progress reports that contain data collected from the project team.
- Where progress deviates significantly, and this usually means outside of a predetermined tolerance limit, it is important to identify the underlying causes and take corrective action.Fig. 3.3 shows the project monitoring cycle to be followed at regular intervals of the project duration.

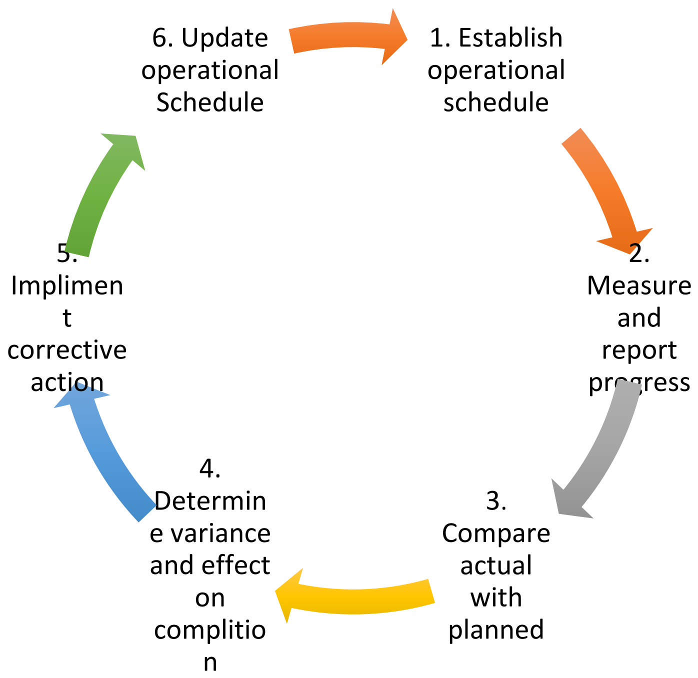

Fig. 3.3 Project monitoring cycle (Source Meredith and Mantel, 2012)

Time Control System

Project time management refers to a component of overall project management in which a timeline is analyzed and developed for the completion of a project (Association for Project Management, 2008). Project time management consists of six different components or steps (PMPA, Guide, 2013).

- Activity Definition– Identifying and scheduling different components of the project management sequence that is required for completion of project deliverables.
- Activity Sequencing– The process of project time management that defines the order in which deliverables must be completed.
- Activity resource estimation– Identifying and defining the types and quantities of resources and materials required to complete a deliverable.
- Activity duration estimation– Identifying and estimating the timeline for completion of durables.
- Schedule Development- the analysis of the order of activities, timelines, resources, and schedule barriers to develop a project Schedule.
- Schedule Control– Project management intervention to mitigate changes to the product schedule

The project time management process is dynamic and may require input from several different teams with individual project time management process in order to integrate the various interdependent components of the project to achieve the project deliverable(s). The processes are repeated within each work package of the project or occur at least once within the project as a whole (Association for Project Management, 2008).

Some causes of project schedule overruns are as follows

- **Multitasking** Working on many task for project dissipates focused energy, causing some task to be delayed.
- **Procrastination** Given a choice between two scheduled times, one early and one late, the human tendency is to wait until the last time to begin. Hence schedule for the earliest time.
- **Task Variability** the time to complete a task is variable; some task will be completed sooner than expected; others later. Due to late tasks the project schedule gets affected.

The following are guidelines for controlling schedule variability and keeping projects on schedule (Association for Project Management, 2008).

i. Fight the tendency to multitask Assign priorities then work continuously on one task or project at a time until completed.
ii. Include time buffers in the schedule A time buffer is a schedule reserve, and amount of time included in the expected duration to account for variability in completion time.
iii. Frequently report the expected completion time For adequately preparing activities to start at the earliest possible time, information on the progress of their predecessors is necessary.
iv. Published consequences of Scheduled delays All project team members, sub-contractor and suppliers should be informed about the consequences of running the schedule and the possible benefits of being on schedule.

Cost Control

Cost management is concerned with the process of planning and controlling the budget of a project or business. It includes activities such as planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the approved budget (Meredith and Mantel, 2012).

Following are some of the valuable and essential techniques used for efficient project cost control

- **Planning the Project Budget** You would need to ideally make a budget at the beginning of the planning session with regard to the project at hand. It is this budget that you would have to help you for all payments that need to be made and costs that you will incur during the project life cycle. The making of this budget therefore entails a lot of research and critical thinking.Like any other budget, you would always have to leave room for adjustments as the costs may not remain the same right through the period of the project. Adhering to the project budget at all times is key to the profit from project.
- **Keeping a Track of Costs** Keeping track of all actual costs is also equally important as any other technique. Here, it is best to prepare a budget that is time-based. This will help you keep track of the budget of a project in each of its phases. The actual costs will have to be tracked against the periodic targets that have been set out in the budget. These targets could be on a monthly or weekly basis or even yearly if the project will go on for long.This is much easier to work with rather than having one complete budget for the entire period of the project. If any new work is required to be carried out, you would need to make estimations for this and see if it can be accommodated with the final amount in the budget. If not, you may have to work on necessary arrangements for 'Change Requests', where the client will pay for the new work or the changes.
- **Effective Time Management** Another effective technique would be effective time management. Although this technique does apply to various management areas, it is very important with regard to project cost control. The reason for this is that the cost of your project could keep rising if you are unable to meet the project deadlines; the longer the project is dragged on for, the higher the costs incurred which effectively means that the budget will be exceeded. The project manager would need to constantly remind his/her team of the important deadlines of the project in order to ensure that work is completed on time
- **Project Change Control** Project change control is yet another vital technique. Change control systems are essential to take into account any potential changes that could occur during the course of the project. This is due to the fact that each change to the scope of the project will have an impact on the deadlines of the deliverables, so the changes may increase project cost by increasing the effort needed for the project.
- **Use of Earned Value** Similarly, in order to identify the value of the work that has been carried out thus far, it is very helpful to use the accounting technique commonly known as 'Earned Value'. This is particularly helpful for large projects and will help you make any quick changes that are absolutely essential for the success of the project (PMPA, Guide, 2013).

The Additional Steps for Project Cost Control (Meredith and Mantel, 2012)

i. It is advisable to constantly review the budget as well as the trends and other financial information. Providing reports on project financials at regular intervals will also help keep track of the progress of the project.
ii. This will ensure that overspending does not take place, as you would not want to find out when it is too late. The earlier the problem is found, the more easily and quickly it could be remedied.
iii. All documents should also be provided at regular intervals to auditors, who would also be

able to point out to you any potential cost risks.

Time Cost Trade Off

Trade-offs is the result of a process where the team evaluates options for the project and decides which approach best meets the project's goals (Meredith and Mantel, 2012).

The objective of the time-cost trade-off analysis is to reduce the original project duration, determined form the critical path analysis, to meet a specific deadline, with the least cost. In addition to that it might be necessary to finish the project in a specific time to

i. Finish the project in a predefined deadline date.
ii. Recover early delays.
iii. Avoid liquidated damages.
iv. Free key resources early for other projects.
v. Avoid adverse weather conditions that might affect productivity.
vi. Receive an early completion-bonus.
vii. Improve project cash flow

Reducing project duration can be done by adjusting overlaps between activities or by reducing activities duration. What is the reason for an increase in direct cost as the activity duration is reduced? A simple case arises in the use of overtime work. By scheduling weekend or evening work, the completion time for an activity as measured in calendar days will be reduced. However, extra wages must be paid for such overtime work, so the cost will increase. Also, overtime work is more prone to accidents and quality problems that must be corrected, so costs may increase. The activity duration can be reduced by one of the following actions (Meredith and Mantel, 2012)

I. Applying multiple-shifts work.
II. Working extended hours (over time).
III. Offering incentive payments to increase the productivity.
IV. Working on weekends and holidays.
V. Using additional resources.
VI. Using materials with faster installation methods.
VII. Using alternate construction methods or sequence

Activity Time-Cost Relationship

In general, there is a trade-off between the time and the direct cost to complete an activity; the less expensive the resources, the larger duration they take to complete an activity. Shortening the duration on an activity will normally increase its direct cost which comprises the cost of labor, equipment, and material. It should never be assumed that the quantity of resources deployed and the task duration are inversely related. Thus one should never automatically assume that the work that can be done by one man in 16 weeks can actually be done by 16 men in one week.

A simple representation of the possible relationship between the duration of an activity and its direct costs appears in Fig. 3.4. Considering only this activity in isolation and without reference to the project completion deadline, a

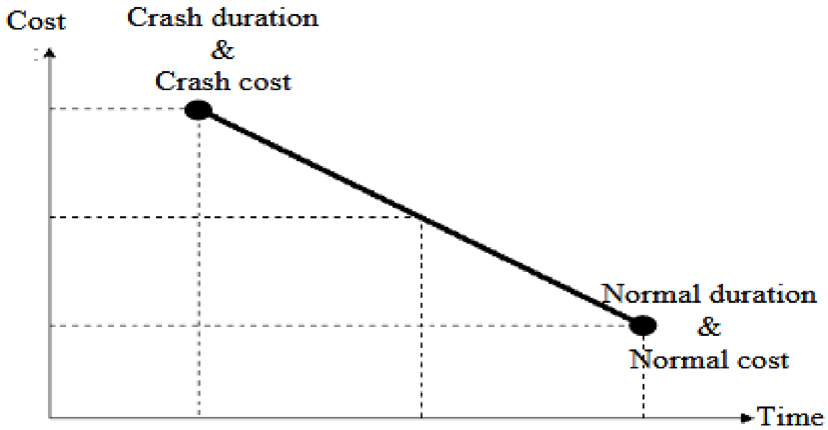

Fig. 3.4 Illustration of linear time/cost trade-off for an activity (Source Meredith and Mantel, 2012)

Manager would choose a duration which implies minimum direct cost, called the normal duration. At the other extreme, a manager might choose to complete the activity in the minimum possible time, called crashed duration, but at a maximum cost(PMPA, Guide, 2013).

The linear relationship shown in the above figure, between these two points implies that any intermediate duration could also be chosen. It is possible that some intermediate point may represent the ideal or optimal trade-off between time and cost for this activity. The slope of the line connecting the normal point (lower point) and the crash point (upper point) is called the cost slope of the activity. The slope of this line can be calculated mathematically by knowing the coordinates of the normal and crash points (Meredith and Mantel, 2012).

Cost slope = crash cost – (normal cost / normal duration) – crash duration

The least direct cost required to complete an activity is called the normal cost (minimum cost), and the corresponding duration is called the normal duration. The shortest possible duration required for completing the activity is called the crash duration, and the corresponding cost is called the crash cost. Normally, a planner starts his/her estimation and scheduling process by assuming the least costly option.

3.4 Project Procurement and Material Management

Procurement is the act of obtaining goods, supplies, and/or services. Therefore, project procurement is obtaining all of the materials and services that are required for the project (PMPA, Guide, 2013).. Project procurement management encompasses the processes used for making sure project procurement is successful.

Objectives of procurement system

I. Acquire needed supplies as inexpensively as possible
II. Obtain high quality supplies
III. Assure prompt & dependable delivery
IV. Distribute the procurement workload to avoid period of idleness & overwork
V. Optimize inventory management through scientific procurement procedures

Project procurement management includes three primary processes

1. Plan procurements
2. Conduct procurements
3. Administer (or control) procurements

1. **Plan Procurements**

This includes planning for the following questions

a) What are all the materials and services you will require for the project? This includes all specifications of the materials and services,

b) What can be provided by your company, and what should you purchase elsewhere? Even when your company can do something in-house, there may be a benefit of choosing to outsource such as cost savings, faster delivery, etc.

c) What are your contract requirements for outside purchases?

d) Do you have required delivery dates?

e) Do you want a fixed price contract or cost-reimbursable?

f) Are there key milestones to be included?

g) What about legal terms and conditions that must be met?

h) How will you search for suppliers of the materials or services you need?

i) Will you release a request for proposal (RFP)?

j) Do you have a preferred supplier?

k) What are the criteria for who will win the work?

l) Will it be based on price if all contract requirements are met?

m) Is there another way to evaluate bidders?

2. Conduct Procurements

This is the execution phase of project procurement management. It's when the RFPs are released, bids are gathers, and selections are made. Any vendor negotiations will occur during this phase, and then the agreed-upon contracts are signed. Conducting procurements also includes the actual receipt of and payment for goods and services (PMPA, Guide, 2013).

3. Administer (or control) Procurements

The control or administer procurements process is focused on monitoring and controlling project procurements to ensure all requirements are met.

Two key steps included in this process are

a) Status or progress updates from vendors

b) Quality checks of products or services delivered

Schedule and cost monitoring for procurements are also part of this process. Any changes and their impact on the overall project schedule and budget are monitored here.

Material Management

It is concerned with planning, organizing and controlling the flow of materials from their initial purchase through internal operations to the service point through distribution. Material management is a scientific technique, concerned with Planning, Organizing &Control of flow of materials, from their initial purchase to destination (PMPA, Guide, 2013).

The aim of material management to get following

I. The right quality
II. Right quantity of supplies
III. Delivery at the right time
IV. At the right place
V. For the right cost

Four Basic Needs of Material Management

1. To have adequate materials on hand when needed.
2. To pay the lowest possible prices, consistent with quality and value requirement for purchases materials.
3. To minimize the inventory investment.
4. To operate efficiently.

Inventory Control

It means stocking adequate number and kind of stores, so that the materials are available whenever required and wherever required. Scientific inventory control results in optimal balance (PMPA, Guide, 2013).

Functions of Inventory Control

i. To provide maximum supply service, consistent with maximum efficiency & optimum investment.
ii. To provide cushion between forecasted & actual demand for a material.

Economic Order of Quantity

EOQ = Average Monthly Consumption X Lead Time [in months] + Buffer Stock – Stock on hand

Re-order level stock level at which fresh order is placed

i. Average consumption per day x lead time + buffer stock

ii. Lead time Duration time between placing an order & receipt of material

3.5 The Pre-Feasibility Study

A pre-feasibility study should be viewed as an intermediate stage between a project opportunity study and a detailed feasibility study, the difference being primarily the extent of details of the information obtained(Cleland &Gareis, 2006).

It is the process of gathering facts and opinions pertaining to the project. This information is then vetted for the purpose of tentatively determining whether the project idea is worth pursuing furthering.

Pre-feasibility study lays stress on assessing market potential, magnitude of investment, technical feasibility, financial analysis, risk analysis etc. The breadth and depth of pre-feasibility depend upon the time available and the confidence of the decision maker. Pre-feasibility studies help in preparing a project profile for presentation to various stakeholders including funding agencies to solicit their support to the project. It also throws light on aspects of the project that are critical in nature and necessitate further investigation through functional support studies.

Support studies are carried out before commissioning pre-feasibility or a feasibility study of projects requiring large-scale investments. These studies also form an integral part of the feasibility studies. They cover one or more critical aspects of project in detail. The contents of the Support Study vary depending on the nature of the study and the project contemplated. Since it relates to a vital aspect of the project the conclusions should be clear enough to give a direction to the subsequent stage of project preparation.

3.6 Feasibility Study

Feasibility Study forms the backbone of Project Formulation and presents a balanced picture incorporating all aspects of possible concern (PMPA, Guide, 2013).

The study investigates practicalities, ways of achieving objectives, strategy options, methodology, and predict likely outcome, risk and the consequences of each course of action. It becomes the foundation on which project definition and rationale will be based so that the quality is reflected in subsequent project activity.

A well conducted study provides a sound base for decisions, clarifications of objectives, logical planning, minimal risk, and a successful cost effective project. Assessing feasibility of a proposal requires understanding of the STEEP factors. These are as under Social, Technological, Ecological, Economic, and Political (PMPA, Guide, 2013).

A feasibility study is not an end in itself but only a means to arrive at an investment decision. The preparation of a feasibility study report is often made difficult by the number of alternatives (regarding the choice of technology, plant capacity, location, financing etc.) and assumptions on which the decisions are made. The project feasibility studies focus on

i. Economic and Market Analysis
ii. Technical Analysis
iii. Market Analysis
iv. Financial Analysis
v. Economic Benefits
vi. Project Risk and Uncertainty
vii. Management Aspects

Project Break Even Point

Break-Even analysis is used to give answers to questions such as “what is the minimum level of sales that ensure the project will not experience loss” or “how much can sales be decreased and the project still continue to be profitable” (PMPA, Guide, 2013).

Break-even analysis is the analysis of the level of sales at which a company (or a project) would make zero profit. As its name implies, this approach determines the sales needed to break even.

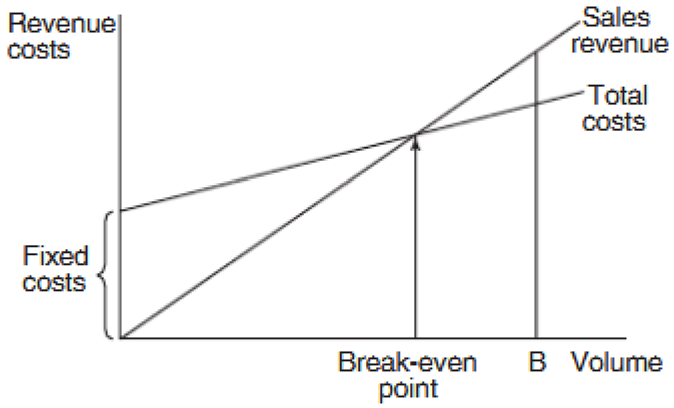

Fig. 3.5 Break Even analysis (Source Meredith and Mantel, 2012)

Break-Even point (B.E.P.) is determined as the point where total income from sales is equal to total expenses (both fixed and variable). In other words, it is the point that corresponds to this level of production capacity, under which the company operates at a loss (Fig. 3.5).

If all the company's expenses were variable, break-even analysis would not be relevant. But, in practice, total costs can be significantly affected by long-term investments that produce fixed costs. Therefore, a company – in its effort to produce gains for its shareholders – has to estimate the level of goods (or services) sold that covers both fixed and variable costs(PMPA, Guide, 2013)..

The Break Even Diagram

- To calculate a break-even point based on units Divide fixed costs by the revenue per unit minus the variable cost per unit. The fixed costs are those that do not change no matter how many units are sold. The revenue is the price for which you're selling the product minus the variable costs, like labor and materials (PMPA, Guide, 2013).

  Break-Even Point (Units) = Fixed Costs ÷ (Revenue per Unit – Variable Cost per Unit)

- When determining a break-even point based on sales price Divide the fixed costs by the contribution margin. The contribution margin is determined by subtracting the variable costs from the price of a product. This amount is then used to cover the fixed costs.

Break-Even Point (sales in Rs.) = Fixed Costs ÷ Contribution Margin

Contribution Margin = Price of Product – Variable Costs

To get a better sense of what this all means, let's take a more detailed look at the formula components.

a) Fixed costs as noted above, fixed costs are not affected by the number of items sold, such as rent paid for storefronts or production facilities, computers, and software. Fixed costs also include fees paid for services like graphic design, advertising, and public relations.

b) Contribution Margin The contribution margin is calculated by subtracting an item's variable costs from the selling price. So if you're selling a product for Rs 1000 and the cost of materials and labor is Rs 400, then the contribution margin is Rs 600. This Rs 600 is then used to cover the fixed costs, and if there is any money left after that, it's your net profit.

c) Contribution Margin Ratio This figure, usually expressed as a percentage, is calculated by subtracting your fixed costs from your contribution margin. From there, you can determine what you need to do to break even, like cutting production costs or raising your prices.

Profit earned following your break-even once your sales equal your fixed and variable costs, you have reached the break-even point, and the company will report a net profit or loss of Rs 0. Any sales beyond that point contribute to your net profit (Passenheim, 2009).

Summary

Project execution is one of the important steps of project management cycle. Developing team and assigning resources are steps of project execution. The project management information system (PMIS) is used to plan schedules, budget and execute work to be accomplished in project management. PMIS are system tools and techniques used in project management to deliver information.

The Monitoring and Controlling process oversees all the tasks and metrics necessary to ensure that the approved and authorized project is within scope, on time, and on budget so that the project proceed with minimal risk. Project time management refers to a component of overall project management in which a timeline is analyzed and developed for the completion of a project.

Cost management is concerned with the process of planning and controlling the budget of a project or business. It includes activities such as planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the approved budget. Project procurement is obtaining all of the materials and services that are required for the project. Project procurement management encompasses the processes used for making sure project procurement is successful.

Material management is a scientific technique, concerned with Planning, Organizing &Control of flow of materials, from their initial purchase to destination. Pre- feasibility study is the process of gathering facts and opinions pertaining to the project. Pre-feasibility studies help in preparing a project profile for presentation to various stakeholders. Break-even analysis is the analysis of the level of sales at which a project would make zero profit.

Chapter 4- Monitoring a Waste-based Project

Objectives

- To understand quality and quality management
- To understand team management and diversity management
- To understand change management
- To understand risk planning and risk control

Structure

4.1 Conflict Resolution

4.2 Team Management and Diversity Management

4.3 Change management

4.4 Qualitative risk analysis

4.5 Risk planning and Risk control

To Do Activities

1. Discuss how a project manager should handle conflict in project
2. Compare change management and project management
3. Discuss how a project manager should take care of diversity in team management
4. Why risk management is very important? Discuss.
5. Discuss about any one organization facing risks.
6. Make a survey report of any one nearby organization to study its team management and diversity.
7. Make a report on change management of any one orgnisation.

4.1 Conflict Resolution

Project managers routinely deal with conflict, both from internal and external sources(PMBOK Guide, 2004). Conflict is "a situation of competition in which the parties are aware of the incompatibility of potential future positions and in which each party wishes to occupy a position which is incompatible with the wishes of the other."

Conflict is viewed as a cycle "As with any social process, there are causes; also, there is a core process, which has results or effects. These effects feed back to effect the cause." To understand conflict further, the situation must include elements of interdependence, emotions, perceptions, and behaviors. For example, conflict occurs between parties whose tasks are interdependent, who are angry with each other, who perceive the other party as being at fault, and whose actions cause a business problem (PMBOK Guide, 2004).

Benefits of Conflict

- ❖ Conflict can be constructive and healthy for an organization (Meredith & Mantel, 2012).
- ❖ It can aid in developing individuals and improving the organization by building on the individual assets of its members.
- ❖ Conflict can bring about underlying issues.
- ❖ It can force people to confront possible defects in a solution and choose a better one (PMBOK Guide, 2004).
- ❖ The understanding of real interests, goals and needs is enhanced and ongoing communication around those issues is induced.
- ❖ In addition, it can prevent premature and inappropriate resolution of conflict.
- ❖ Constructive conflict occurs when people change and grow personally from the conflict, involvement of the individuals affected by the conflict is increased, cohesiveness is formed among team members, and a solution to the problem is found.

However, if conflict is not managed properly, it can be detrimental to an organization by threatening organizational unity, business partnerships, team relationships, and interpersonal connections (Meredith & Mantel, 2012). Deconstructive conflict occurs when a decision has not been found and the problem remains, energy is taken away from more important activities or issues, morale of teams or individuals is destroyed, and groups of people or teams are polarized (PMBOK Guide, 2004).

Dynamics of Conflict

It is important for a project manager to understand the dynamics of conflict before being able to resolve it. The internal characteristics of conflict include perception of the goal, perception of the other, view of the other's actions, definition of problem, communication, and internal group dynamics (Cloke, 2000).

- Perception of the goal becomes a problem when success becomes competitive or "doing better than the other guy." The focus is placed on the solution rather than attaining the goal.
- Perception of the other can create conflict when the attitude becomes "us versus them." Similarities and differences are emphasized causing division within a group.
- View of other's actions can be a problem when the situation is competitive instead of cooperative. Behavior can be suspicious in a competitive environment.
- Definition of problem can result in conflict when the size of the problem is escalated, issues are misconstrued, and original issues are lost.
- Communication in a competitive environment can cause mistrust and information may be withheld or may be lacking. Communication is not open and honest.
- Internal group dynamics can be negative when the group structure is centralized and rigid rather than safe and open. Conformity is emphasized and tasks dominate over the needs of the team members (Cloke, 2000).

These characteristics can strongly influence the behavior style of group members and affect the potential outcome of the conflict. In some instances, the project manager’s lack of skills to effectively manage and resolve conflict can be the problem

Approaches to Conflict Resolution in Project Management

A Systems Approach to Planning, Scheduling, and Controlling, five modes for conflict resolution are explained and the situations when they are best utilized are identified (Cloke, 2000).

These modes are

1. Confronting
2. Compromising
3. Smoothing
4. Forcing
5. Avoiding

Confronting

This is also described as problem solving, integrating, collaborating or win-win style. It involves the conflicting parties meeting face-to-face and collaborating to reach an agreement that satisfies the concerns of both parties. This style involves open and direct communication which should lead the way to solving the problem. Confronting should be used when

- Both parties need to win.
- You want to decrease cost.
- You want create a common power base.
- Skills are complementary.
- Time is sufficient.
- Trust is present.
- Learning is the ultimate goal.

Compromising

This is also described as a “give and take” style. Conflicting parties bargain to reach a mutually acceptable solution (Baan et al, 2014). Both parties give up something in order to reach a decision and leave with some degree of satisfaction. Compromising should be used when

- Both parties need to win.
- You are in a deadlock.
- Time is not sufficient.
- You want to maintain the relationship among the involved parties.
- You will get nothing if you do not compromise.
- Stakes are moderate.

Smoothing

This is also referred to as accommodating or obliging style. In this approach, the areas of agreement are emphasized and the areas of disagreement are downplayed. Conflicts are not always resolved in the smoothing mode. A party may sacrifice its own concerns or goals in order to satisfy the concerns or goals of the other party. Smoothing should be used when

- Goal to be reached is overarching.
- You want to create obligation for a trade-off at a later time.
- Stakes are low.
- Liability is limited.
- Any solution is adequate.
- You want to be harmonious and create good will.
- You would lose anyway.
- You want to gain time.

Forcing

This is also known as competing, controlling, or dominating style. Forcing occurs when one party goes all out to win its position while ignoring the needs and concerns of the other party. As the intensity of a conflict increases, the tendency for a forced conflict is more likely (Baan et al, 2014). These results in a win-lose situation where one party wins at the expense of the other party. Forcing should be used when

- A "do or die" situation is present.
- Stakes are high.
- Important principles are at stake.
- Relationship among parties is not important.
- A quick decision must be made.

Avoiding

This is also described as withdrawal style. This approach is viewed as postponing an issue for later or withdrawing from the situation altogether. It is regarded as a temporary solution because the problem and conflict continue to reoccur over and over again. Avoiding should be used when

- You cannot win.
- Stakes are low.
- Stakes are high, but you are not prepared.
- You want to gain time.
- You want to maintain neutrality or reputation.
- You think problem will go away.

- You win by delaying.

There are three main methods for resolving conflict avoiding the conflict, defusing the conflict, or using confrontation to draw out the causes of conflict, usually through the use of problem-solving meetings.

4.2 Team Management and Diversity Management

Team Diversity is the significant uniqueness of each individual on a team. This should not only include the usual diverse selections such as religion, sex, age, and race, but also additional unique personality characteristics such as introverts and extroverts, liberals and conservatives, etc. All of these differences can affect team interactions and performance. However, not all differences affect team performance (Pledger, Marcia, 2006).

Aside from the actual differences that create diversity, diverse teams have different challenges, benefits, and pitfalls than homogeneous ones. The main benefit is that a diverse background fosters a creative environment. The main pitfall is that differences between team members can lead to destructive violence.

The differences that are most commonly thought of as separating diverse teams from homogeneous ones are easily observed stereotypes. The following list categorizes the physical and social differences (excluding actual workplace experience) that most frequently create a diverse environment (Pledger, Marcia, 2006).

Gender

Gender communication issues can strongly affect team interactions. Gender communication issues can range from communication styles and perceptions, opportunities and even sexual harassment.

Race

Race is defined as a group of people, often of a common geographic origin, that share genetically transmitted physical characteristics. Racism is the belief that these inherited characteristics affect an individual's behavior or abilities.

Cultural

Culture refers to the standards of social interaction, value and beliefs from a given group of people. Cultural issues can affect team interactions through different understandings of communication or family and can appear to be an excuse for preferential treatment.

Age

Age can be a concern along the entire spectrum; is someone too young or too old to do a job? It also creates the potential for communication problems based on different levels of experience, and for prejudicial treatment based on age.

Sexual Orientation

With the increasing visibility of gender minorities such as lesbian, gay, bisexual, transgender, there are increasing workplace issues. From simply not understanding gender differences, to being morally opposed to them, sexual orientation can create blocks to productive team interactions.

Disabilities

Differences in ability often create difficulties in communication and emotional interactions. Whether it is a deaf individual not being able to communicate with hearing individuals, or a hearing individual being unsure of how to approach a deaf individual, disabilities present a variety of issues in team organizations (Pledger, Marcia, 2006).

Diversity means that there will be an increased likelihood for a wider range of views to be present. This includes views that are likely to challenge widely accepted views of the team and its culture. The existence of these diverse views is essential to the process of organizational change. In addition, as teams are becoming increasingly global, diversity can help an organization or team to understand its place in its surroundings (Pledger, Marcia, 2006).

The differences inherent in a diverse team environment also cause challenges. The benefits of having diverse backgrounds do not occur without having team members that are dedicated to success and a common goal. The preconceived notions about differences in other people, such as racism, sexism, ageism, homophobia, etc, disrupt work processes and can prevent teams from achieving their goals. Simple misunderstandings can arise from basic cultural differences, communication styles or work attitudes, and create challenge.

Diversity in teams has benefits and creates challenges. However, by being aware of these challenges and how to address them, teams and team managers can overcome them and reach success.

Leaders need to develop a common focus. Most people realize that everyone is different; however, by focusing on the job at hand, leaders can take the focus off the differences that are present. As teams achieve successful results they develop a bond which helps to solidify the team, and overcome differences.

Managing Diversity

A team leader must think about diversity as diversity of ideas and experience, not just race and gender. A leader needs to recognize the diversity of each team member and achieve unity of common goals without destroying the uniqueness of any person (Pledger, Marcia, 2006). The team leader must do this within the scope of the organization's resources relative to the growth of the team member.

Most problems in the work place are not that people cannot do their jobs. Rather it is that people cannot get along with others. The team leader should make efforts in effectively training soft skills. This includes such subjects as diversity, communication and people skills that allow people to understand each other and develop good team skills (Maccoby, Michael, 2006).

Every team member must not only be able to understand and work with all the other team members, but they must also want to. Embracing diversity is the first step to managing a truly diverse team. In order to facilitate this, team leaders should consider the following (Maccoby, Michael, 2006)

- Develop an atmosphere in which it is safe for all employees to ask for help. People should not be viewed as weak if they ask for help. Joining weakness with strengths to get a goal or objective accomplished is one aspect of building great teams. One person's weakness should be another person's strength.

- Actively seek information from people from a variety of backgrounds and cultures in order to develop a broad picture.
- Include everyone on the problem solving and decision making process.
- Include people who are different than you in informal gatherings such as lunch, coffee breaks and spur of the moment meetings.
- Create a team spirit in of which every member feels a part.

A team leader enables the other members to be innovative as well as self-directed within the capacity of individual assignments and allows them to learn from their own, as well as others' successes, mistakes and failures. It is important to assure that each individual on the team has the opportunity to make the maximum contribution to the success of the team by doing the type of work for which s/he has the greatest opportunity for productivity and achievement (Maccoby, Michael, 2006).

Leaders have the task of using the other team members' diverse gifts, abilities, and skills to achieve the common goal without the unintended consequence of conforming to the characteristics the others on the team. This requires active management by the leader to insure that diverse followers show respect and acceptance of the followers that are different in one way or another (Maccoby, Michael, 2006).

If team members do not accept others for what they are, they will be unable to use the abilities of each team member to fill in their own weak areas. Hence, the team effort develops knowledge and skill gaps that often lead to failure. Their only goal becomes the ones on their personal agendas while ignoring the needs of the team and the organization. Creating an environment that encourages diversity enables team members to accept every individual on the team and helps them realize that it takes a variety of people to become the best. This kind of environment also enforces the need to rely on everyone within the team, no matter how different another person may be. These characteristics and experiences make a worker unique. Diversity occurs when the whole team sees all these unique characteristics, and realizes that workers are more valuable because of their differences (Pledger, Marcia, 2006).

Quality

Quality has been defined as "the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs (Patterson, 1983).

Quality management is the process for ensuring that all project activities necessary to design, plan and implement a project are effective and efficient with respect to the purpose of the objective and its performance. Project quality management (QM) is not a separate, independent process that occurs at the end of an activity to measure the level of quality of the output

Quality and grade are not the same, grade are characteristics of a material or service such as additional features. A product may be of good quality (no defects) and be of low grade (few or no extra features).

Quality management is a continuous process that starts and ends with the project. It is more about preventing and avoiding than measuring and fixing poor quality outputs. It is part of every project management processes from the moment the project initiates to the final steps in the project closure phase (Patterson, 1983).

Quality management is not an event - it is a process, a consistently high quality product or service cannot be produced by a defective process. Quality management is a repetitive cycle of measuring quality, updating processes, measuring, updating processes until the desired quality is achieved.

Quality Management for Projects (Patterson, 1983)

Project Quality Management has three key processes that you should perform in projects.

1. Plan Quality

Plan Quality involves identifying the quality requirements for both the project and the product and documenting how the project can show it is meeting the quality requirements. The outputs of this process include a Quality Management Plan, quality metrics, quality checklists and a Process Improvement Plan.

2. Perform Quality Assurance

Quality Assurance is used to verify that the project processes are sufficient so that if they are being adhered to the project deliverables will be of good quality. *Process checklists* and *project audits* are two methods used for *project quality assurance*.

3. Perform Quality Control

Quality Control verifies that the product meets the quality requirements. *Peer reviews* and *testing* are two methods used to perform quality control. The results will determine if corrective action is needed.

As the project manager, there are three key quality management concepts that will help to deliver a high quality project

I. Customer Satisfaction

II. Prevention over Inspection

III. Continuous Improvement

Customer Satisfaction

Customer satisfaction is a key measure of a project's quality. It's important to keep in mind that project quality management is concerned with both the *product of the project* and the *management of the project*.

If the customer doesn't feel the product produced by the project meets their needs or if the way the project was run didn't meet their expectations, then the customer is very likely to consider the project quality as poor, regardless of what the project manager or team thinks.

As a result, not only is it important to make sure the project requirements are met, managing customer expectations is also a critical activity that you need to handle well for your project to succeed.

Prevention over Inspection

The Cost of Quality (COQ) includes money spent during the project to avoid failures and money spent during and after the project because of failures. These are known as the Cost of Conformance and the Cost of Nonconformance.

Continuous Improvement

Continuous improvement is a concept that exists in all of the major quality management approaches such as Six Sigma and Total Quality Management (TQM). In fact, it is a key aspect of the last concept, *prevention over inspection*.

Continuous improvement is simply the ongoing effort to improve your products, services, or processes over time. These improvements can be small, incremental changes or major, breakthrough type changes.

From a project perspective, this concept can be applied by analyzing the issues that were encountered during the project for any lessons learned that you can apply to future projects. The goal is to avoid repeating the same issues in other projects.

4.3 Change Management

Change management is a structured approach to moving an organization from the current state to the desired future state. The conversion of outputs into outcomes and benefits invariably requires some form of organizational change. Resistance to change is a natural phenomenon, so managing change in a structured and controlled manner is essential if the benefits in a business case are to be realised.

Organizations respond to change in many different ways. One way of understanding how an organization may react to change is through metaphors. Morgan identified eight organizational metaphors that include regarding an organization as a machine, an organism or a political system.

There are many change management models, such as those of Kotter, Carnall and Lewin. Each model has a different approach and applies different metaphors. Carnall's model, for example, is applicable to organizations that operate like a political system but not those that operate like a machine, whereas Lewin's model is the reverse.

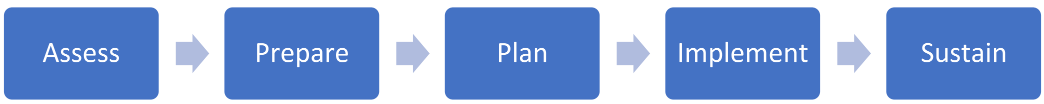

Fig. 4.1 Change management process (Source Passenheim, 2009)

A typical, generic, change management process might include the following steps (Fig. 4.1).

Assess

In change management, the assess step constitutes what is needed to convert outputs into outcomes and benefits.

Prepare

The prepare step involves creating a vision and gaining support. This would form part of the concept phase of a project or programme. This is when stakeholder management is used to gain support for the outline business case, with particular emphasis on changes required to business-as-usual. In the definition phase of a project or programme, this would also include establishing governance and roles to support change, such as the appointment of business change managers.

Plan

The plan step is a familiar process to both P3 managers and change managers. The various P3 plans and schedules must take change into account, particularly in the communication management plan and the risk management plan.

Implement

The implement step is the heart of the process. It includes communicating the benefits of the change, removing obstacles and coordinating the activities that transform business-as-usual from the status quo to the new way of working. Much depends on the organization's readiness for change. This is represented by three key factors

- dissatisfaction with the current situation (A);
- desirability of the proposed change (B);
- practicality of the proposed change (D).

These factors are often included in the formula

$$C = (ABD) > X$$

This demonstrates the fact that, for change (C) to be successful, the combination of A, B and D must be greater than the cost of the change (X).

Sustain

For changes to deliver the benefits required by the business case, they have to be stable and become the normal way of working. The sustain step will continue beyond the P3 life cycle to ensure that value is continually realised from the investment in the project, programme or portfolio.

Projects often conclude with the delivery of an output that is handed over to the client or user organization. The latter then takes responsibility for any change management required to ensure that benefits accrue from the output. This does not necessarily mean that the project has no responsibility for change management. The project management team can support the assessment, preparation and planning steps of the change management process and coordinate with the change management team to facilitate implementation. Where the output of a project and resulting benefit are independent of any other outputs and benefits, then responsibility for benefits management and the change management component may be included in an extended project life cycle.

Project Management and Change Management

It is not enough to merely prescribe the change and expect it to happen; creating change within an organization takes hard work and an understanding of what must actually take place to make the change happen. To begin, let's look at the formal definitions of change management and project management, two key disciplines required to bring a change to life (Fig.4.2). These are two commonly accepted definitions that help us begin to think about these two distinct but intertwined disciplines (PMBOK® Guide, 2004)

Project Management

Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements.

Project management is accomplished through the application and integration of the project management processes of initiating, planning, executing, monitoring and controlling, and closing (PMBOK® Guide, 2004).

Change Management

Change management is the process, tools and techniques to manage the people side of change to achieve the required business outcome.

Change management incorporates the organizational tools that can be utilized to help individuals make successful personal transitions resulting in the adoption and realization of change.

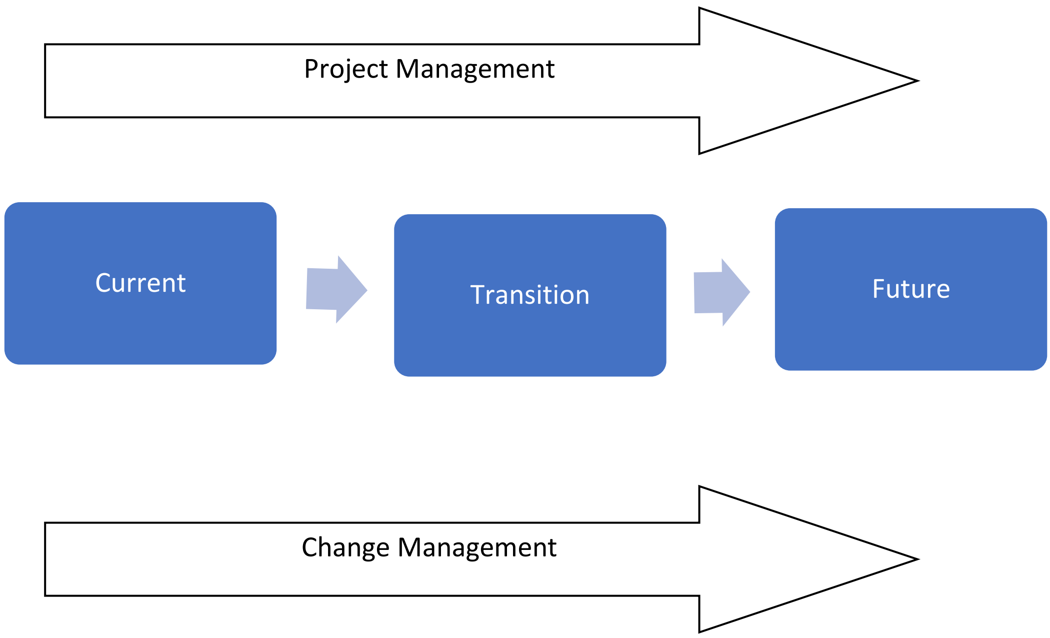

Fig. 4.2 Project management and change management (SourcePassenheim, 2009)

Table 4.1 shows difference between project management and change management.

Table 4.1 Project management and Change management

Discipline	Process	Tools
Project management	Initiating	Statement of work,
	Planning	Project charter,
	Executing	Business case
	Monitoring and controlling	Work breakdown structure
	Closing	Budget estimations
		Resource allocation
		Schedules
		Tracking
		Risk Identification and mitigation
		Reports on performance and compliance
Change management	Planning for change	Individual change model
	Managing change	Communication
	Reinforcing change	Sponsorship
		Coaching
		Training
		Resistance management

4.4 Qualitative Risk Analysis

Risk management plays an important part within project management. Inadequate risk management could have an impact whether the project will succeed or fail. To get an idea of what risk management is, what it means and how to use it as a tool for success, let us define risk (PMBOK® Guide, 2004)

Risk

Risk can be rather difficult to define as expectations are focused on the future and therefore a lot of uncertainties could come into play. So it might be better to start with a definition of uncertainties

Uncertainties = Threats + Opportunities

- Threats are events that have a negative impact on any result.
- Opportunities are events that have a positive impact on results; and
- Uncertainty encompasses the complete range of positive and negative impacts;

Literature often describes risk as"the possibility of suffering harm, loss or danger".

Everybody is confronted with risks in day-to-day activities. For example we could be seriously injured in a car accident if the seat-belts are not fastened. If we are smoking too many cigarettes the possibility of dying of cancer is much higher than for a non-smoker. It is not our nature to think about all the possible risks that may affect us, but risks definitely shape our behaviours (PMBOK® Guide, 2004).

Also, in every project there is the possibility for threats and benefits which may affect the success and/or completion of a project. It is common understanding that a risk is a problem but this is not right. A risk is not a problem until it really occurs. It is more a recognition that a possible problem might occur in the future.

By keeping that in mind the project manager is able to avoid risks by initiating adequate countermeasures. Project risks are those which can cause a project to be delayed or to exceed the planned budget. The field risk management deals with both - positive and negative - aspects of risk. But generally the project team is only concerned with the safety aspects of a project. Therefore very often the negative consequences are the focus of risk management.

Risk Management

Risk management is a procedure to minimize the adverse effect of a possible financial loss by (PMBOK® Guide, 2004)

1. Identifying potential sources of loss;
2. Measuring the financial consequences of a loss occurring and
3. Using controls to minimize actual losses or their financial consequences.

The purpose of monitoring all project risks is to increase the value of each single activity within the project. The potential benefits and threats of all factors connected with these activities have to be ordered and documented. If the project team is aware of the importance of the risk management process, the probability of success will be increased while at the same time failure will become unlikely.

Risk identification is not solely done by the project manager. All relevant stakeholders are involved in keeping an eye on all risks that matter. Generally the risk identification sessions should include as many as the following participants

- Project team
- Risk management team
- Subject matter experts from other parts of the company
- Customers and end-user
- Other project managers and stakeholders
- Outside experts

The participants may vary but the project team should always be involved because they are dealing with the project every day and therefore need fresh information at any time. Outside stakeholders and experts could provide objective and unbiased information for the risk identification step and are therefore an essential part (PMBOK® Guide, 2004).

Risk identification has to be done throughout all project phases. If it is treated like a one-time event, then the whole project runs the risk of overlooking new emerging problems. The process starts in the project initiation phase where the first risks are identified. In the planning stage the project team determines risks and mitigation measures and documents them. In following stages of resource allocation, scheduling and budgeting the associated reserve planning is also documented (PMBOK® Guide, 2004).

After the initial phase of risk identification, all the risks have to be managed until the project is closed or terminated. New risks will occur as the project matures and the outer and inner environment of the project changes. Should risk probability increase or should the risk becomes real, it is time for the project manager to respond to it. The project team and manager have to think about the problem and develop strategies to deal with the impact of the problem (PMBOK® Guide, 2004).

How the project team will deal with project risks is clearly defined in the early stages of the project, then documented in the project plan and will be executed appropriately during the lifetime cycle of the project. Figure 4.3 illustrates the risk management process.

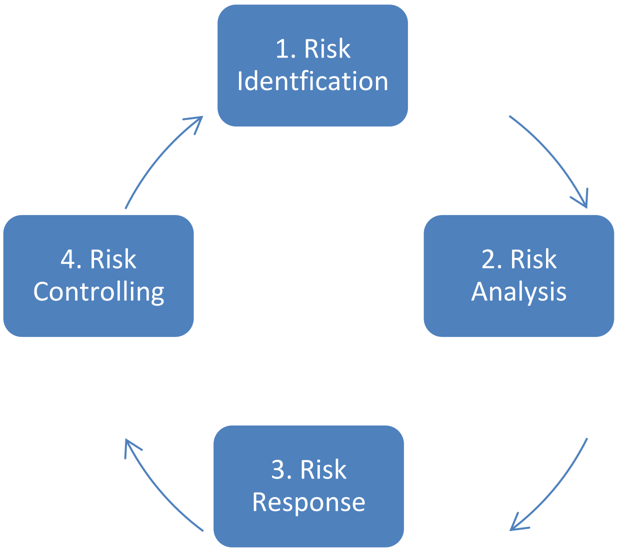

Fig. 4.3 Risk management process (Source Passenheim, 2009)

RiskIdentification

Risk identification is the first and most important step because it builds the basis for all subsequent steps (PMPA, Guide, 2013). The risk identification step is very similar to a transformation process. In the beginning you have inputs and in the end you have a result or simply an output. In the middle step there are tools and techniques to fulfill the transformation process as shown in Fig. 4.4.

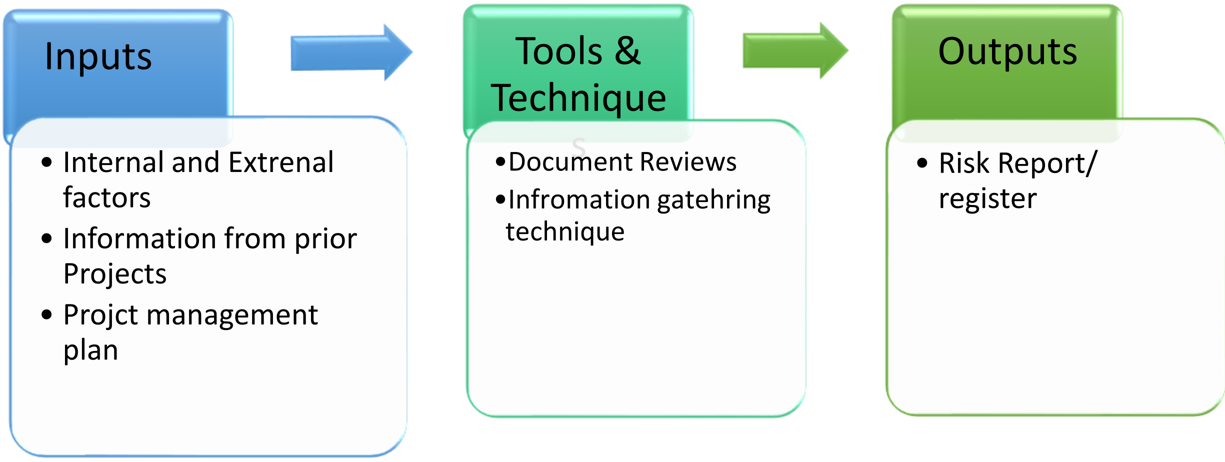

Fig. 4.4 Risk identification Process (SourcePassenheim, 2009)

For the first input for risk, external and internal factors of the project environment have to be considered.

External factors - attributes of the environment

Internal factors- attributes of the (project) organization itself.

Following are the examples for external factors are

- ✓ Economic conditions
- ✓ Social, legal or regulatory trends
- ✓ Political climate
- ✓ Competition – international or domestic
- ✓ Fluctuation in demand
- ✓ Criminal or terroristic activities Typical examples of internal factors are
- ✓ Internal culture
- ✓ Staff capabilities/ numbers
- ✓ Capacity
- ✓ Systems and technology
- ✓ Procedures and processes
- ✓ Communication effectiveness
- ✓ Leadership effectiveness
- ✓ Risk appetite

Information from prior projects usually records experience, developments, hints, failures and risks of those former projects which are now useful in helping to identify risks in the new project. The end documentation from recent projects ("lessons learnt") is a first step for gathering structured information. If kept in an (electronic) archive it is very useful in the preparation of future projects. If you start to review these documents at the beginning of a project it may lead to ideas on how you can improve your project and the organization of the project itself (PMPA, Guide, 2013).

The project management plan is a formal and approved document which serves the project manager as a guideline in project execution and control. The project plan includes planning, assumptions and decisions, sets the communication ways among all stakeholders and records the approved scope, cost and schedule baselines (PMPA, Guide, 2013).

The risk identification step requires that every relevant stakeholder has a complete understanding of the project. Only then are you able to consider the project from different perspectives and identify risks you wouldn't be able to identify without reading it. Within the Tools & Techniques step , one can start with the documentation review to analyze information that already exists in a written form. In project management it is the project plan and the planning documents

- Project charter
- Project scope
- Work breakdown structure (WBS)
- Project schedule
- Cost estimates
- Resource plan
- Procurement plan
- Assumptions list
- Constraints list

Several information gathering methods can be used to identify risks related to the project.

The major three used are

1. Brainstorming- This is a general information-gathering and creativity technique which helps to identify risks and possible solutions for them. In a brainstorming session a group of team members and subject matter experts are "brainstorming" about possible outcomes and sources of risk. The ideas are generated under the leadership of a facilitator. The brainstorming meeting should be done without interruptions and judgments or criticism of ideas. Very often the ideas are built on other ideas. In the end each identified risk will be categorized and its description will be sharpened. The goal of brainstorming is to obtain a comprehensive list of project risks.

2. The risk breakdown structure- It displays an organized description of any known project risks, arranged by a number of categories and their characteristics in the vertical branches. Usually it will show all of the risks and their possible causes.

3. The SWOT analysis (Strength, weakness, opportunity and Threat)- It is also used to define possible risks. SWOT is an abbreviation and looks for strengths, weaknesses, opportunities and threats. Often SWOT is used as a basis for brainstorming. By defining strengths and opportunities, ideas of known or predictable weaknesses and threats will come to mind. SWOT can be used for companies, their departments and divisions as well as for individual people. An advantage of SWOT analysis is that it is simple and relatively cheap except the time needed for it. It helps in generating new ideas. On the other hand the advantage is also the disadvantage as the easiness means that there is no detailed information about how to reach an objective or how important a threat is. A careful use of the outcome of the SWOT

analysis is therefore highly recommended.

These tools and techniques help the project manager to gather relevant information, analyze it and identify risks and opportunities for the aim of the project, its scope, cost and budget. The information will then be stated on the so-called risk report/register, which is the main output of the risk identification step (PMPA, Guide, 2013).

The risk report / register includes all identified risks and their description, risk categories, their causes, the probability of an occurrence, the single impacts of certain risks, possible responses, and their root causes.

The whole risk identification process has four main entries on the risk register

1. Lists of identified risks – Identified risks with their root causes and risk assumptions are listed
2. List of potential responses – Potential responses identified here will serve as inputs to the risk response planning process
3. Root causes of risk - Root causes of risk are fundamental conditions which cause the identified risk
4. Updated risk categories - The process of identifying risks can lead to new risk categories being added

The risk identification should be done in a methodical way. This has to be done to ensure that all important activities and possible consequences related to these activities are identified.

4.4 Risk Analysis

The basis of risk analysis is the above explained risk identification (PMPA, Guide, 2013). Risk analysis covers a complete and continuous evaluation which should be realized quantitatively as well as qualitatively for all identified risks. The goal is to detect possible interrelationships and enable the project manager to identify a kind of importance order, also called prioritizing.

The evaluation of the risks should meet the following demands

1. Objectivity The reference to the special market should be taken into consideration to make the objectivity practicable. For internal risks a subject evaluation is often necessary.

2. Comparability The evaluation of risks should lead to comparable results. Therefore the organization should use consistent and standardized methods and data.

3. Quantification By means of quantification the organization is able to detect deviation from the targeted goal.

4. Consideration of interdependencies In practice this is the hardest part of risk assessment. Effects like compensation and interdependencies can emerge. Not realizing connections between risks and their meaning for the department and possibly for the whole organization can be a big risk. That is why the project team should consider carefully what a risk and the reaction to it can mean not only for the team but for the whole organization as a good solution for one department can mean a problem for another department (PMPA, Guide, 2013).

The most commonly used technique for risk analyzing is the so-called scenario analysis. This simply consists of the probability of the event and the impact this would have on the project. The scenario analysis is part of many more approaches to the analysis of risks, for example in the matrix, the failure mode and effects analysis (FMEA) or the program evaluation and review technique (PERT).

To do a risk evaluation properly it should be defined first which levels will be used for evaluating the risks. For example, there should be ranges between 1 and 5 to give the impact or the likelihood a certain "size". If one wants a more detailed evaluation there could also be a range between 1 and 20. If one wants the evaluation to be more exact, there could also be a more exact classification of what a 'very low impact' means. This could be described by letters and for probability or affected costs, percentages could be stated for the different evaluation levels (see Figure 4.5).

Project objectives	1. Very Low	2. Low	3. Moderate	4. High	5. Very High
COST	Insignificant cost increase	< 10% cost increase	10-20% cost increase	20-40% cost increase	> 40% cost increase
TIME	Insignificant time increase	< 5% cost increase	5-10% cost increase	10-20% cost increase	> 20% cost increase
SCOPE	Scope decreses barely noticeable	Minor areaas of scope affected	Major areaas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
QUALITY	Quality degradation barely noticeable	Only very degrading applicatrions are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable	Project and item is affectively useless

Figure 4. 5 Evaluation of Risks (SourcePassenheim, 2009)

The evaluation form can be filled injointly or with the help of an expert. Common techniques are versatile and range from exact point estimations to workshops. Beside the most probable case, also the worst and the best cases are estimated (PMPA, Guide, 2013)..

The FMEA (Failure mode and effects analysis) model is similar to the matrix but extends the impact and probability by the detection possibility, meaning how hard it is to actually realise the occurring risk. The equation enlarged with detection is

Impact x Probability x Detection = Risk Value

To make the equation work each of the dimensions has to be evaluated by a five-point scale. Detection describes the ability of the project team to detect that the risk is threatening. On the 1 to 5 scale, "1" would mean easy to detect and "5" that the detection would probably only take place when it is considered too late. The product of the data would have a range between 1 and 125. '1' shows the risk has a low probability, an impact of level 1 and would be easy to detect. At the other extreme the result '125' would show that the team had to handle a high-impact risk whose probability is high and nearly impossible to detect. That would mean consideration has to be given whether to start the project or not if the risk could not be mitigated or transferred. All in all, the range between 1 and 125 can be used to define the hazardous nature of a risk.

Risk Response

After having collected all data for the risk control, a risk might occur once. As a result, the project manager has to decide how to react to it. The literature defines five main alternatives between which one can choose mitigate, avoid, transfer, share or retain the risk (PMPA, Guide, 2013).

To mitigate the risk means a reduction of the impact and the possibility of risk occurrence. This is something one can do before starting the whole project. If one detects a risk and knows this risk could be reduced, there are two alternatives the probability of the occurrence could be reduced or the impact the occurred risk would have. Normally, first an attempt is made to reduce the probability and then the impact. The latter is more expensive and perhaps not even necessary to consider if probability could be reduced significantly.

Two terms known especially from engineering projects are testing and prototyping. By testing and prototyping one can test the project in a smaller format with less risk and thereby detect possible failures and problems. With the help of this, the team can prepare for these problems or even eliminate them before starting the real project work (PMPA, Guide, 2013).

Two things that cannot be mitigated easily are cost and time, because money is used up and the days are numbered. But risk management has a solution for this budget reserves and time buffers. Before this is done one always has a kind of safety ratio. This ratio is often directly related to the experience gained from recent projects.

Avoiding risk is already a more drastic approach as the whole project plan might be changed to avoid the particular risk. One should consider carefully whether particular risk warrants changing the plan. An example of avoiding a risk could be using well known technology instead of new, experimental, technology. With the risk transfer, the risk is just moved but not eliminated or dampened. One very common approach is outsourcing which is done far in excess in some industries. Then the contractor has to take the risk.

Also, a well known approach to transferring risks is contracting insurance. This may work well for some specific cases but for project management in general it is not really the right approach. Contracting insurance for a project can be used for low-probability and high-impact events. As these are somehow often Acts of God they are more easily defined (e.g. an earthquake), but for day-to-day business risk insurances they are too expensive and the risks could not be described exactly enough (Passenheim, 2009).

Sharing risk, as the name says, means that different parties share the risks of the same project. One well known example is Airbus - from the aircraft industry. Airbus allocated risk to the R&D departments over different countries like France, Britain and Germany.

Another kind of sharing of risk is signing a BOOT contract. BOOT is an abbreviation for “Build-Own-Operate-Transfer”, meaning the project organization is building the plant and after that the organization is the owner until the operations are running smoothly and the whole check-up is done. Only if all these steps are successful is the ownership transferred to the client (Passenheim, 2009)..

Sharing risks is also one possible way to save money. The approach is often used in the field of logistics. With combining the ideas of the subcontractor with the project team parent’s organization ideas a big improvement could be made, but to reach a level of teamwork where these procedures work, both sides should gain advantages from this relationship. This is also one reason why partnerships can emerge. Then the relationship is good enough to work together closely. Both sides are taking the risk and the benefits coming from new ideas are most probably equal by that stage.

The last option, retaining a risk, seems a bit strange at first sight that, but there are cases where retaining and accepting the risk can be the easiest way to handle it. The possibility of such events occurring is often so low that the risk could be accepted. More often, the impact of the risk is very low and it is easier to buffer it with financial help and just keep on working (Passenheim, 2009).

A contingency plan provides a plan which is fulfilled if one of the known risks becomes reality. With the help of that plan the action that is to be followed is already clear before the risk appears. That helps us to stay calm and get step by step to a solution which can be e.g. reducing or weakening the impact of the event. The contingency plan should then say what, when and where which actions are to be taken. With the help of the contingency plan the manager who has to deal with the occurring problem does not have to invent a solution on the spot, which in any event would be a low quality solution, still taking time to find. It is much easier if one can look into the contingency plan where the steps are described after they have been well thought out during the project planning phase. The availability of a contingency plan can significantly increase the chances for project success.

At first sight it might seem easy just plan the risks and it's done but there are some conditions one has to consider. First of all, proper documentation of the steps is necessary. Within that documentation cost estimations and the probable source should be named. Furthermore, the involved teams should agree on the plan and the allocation of tasks should be clear. All these steps should be followed to ensure all team members know what to do and are committed to the work, especially in case of an emergency.

Having a contingency plan is absolutely necessary. Otherwise a risk might slow the managerial response and any decisions made under pressure will likely be poor and potentially dangerous and costly. One good way to follow all these instructions is to make a note of this information within a so-called risk response matrix. Still, there is a more extreme possibility left which one has to think of during risk contingency planning. There is the possible eventuality that the risk remains after a risk response as per the contingency plan.

4.5 Risk Control

The very last step in the whole risk management process is risk control. Included in this step are executing the risk response strategy, monitoring and triggering events, initiating contingency plans, and continuously watching for new risks. In the risk control portion the change in management systems is also an essential part. During the project there might be changes in scope, budget, and schedule which the project manager has to deal with (Meredith & Mantel, 2012).

It is also the duty of the project manager to monitor all possible risks in just the same way as he/she is interested in the project progress. Risk assessment and updating should be part in every status meeting and progress report system. Also, the project team should have the constant awareness that unpredictable risks may occur. But this is not the usual case in every project.

It is the duty of the project manager to create an environment in which all team members feel free to raise concerns and admit mistakes. This should be the standard in every project, because hiding risks or denying problems is not good for the future success of the company. Everybody should be encouraged to identify problems and new risks and therefore the project manager has to have a positive attitude toward risk (Meredith & Mantel, 2012).

In very complex and huge projects the risk identification and assessment step has to be repeated on a regular basis. Outside stakeholders and experts should be brought into the discussion so that they also can review the actual risk profiles of the project.

Another useful key success factor is the assignment of responsibility for every identified risk. This step could be very complicated in the case where multiple organizations are involved in the project (Meredith & Mantel, 2012). Project audits usually play an important part in the Risk Response Control. An audit can be defined as a systematic and independent analysis. The term “audit” has its origin in the Latin language.

The main aim of the audits is the discovering of weak points and risks inside an organization or project. A big advantage of audits is the ability to check quality-related issues and workflow in a very good way. A disadvantage is the high time demand for the preparation of the paperwork and the training of the employees. However, audits only allow a short snap-shot of the visible situation. Some employees see this as a control over the work they performed and may come to resent the auditor.

Every audit results in an audit report. Internal reports must contain, for example, the basic information and procedures for the evaluation and observations in terms of project documentation or personnel qualification. Of course non-conformities also have to be reported. This is necessary for the next audit in order to check if corrective actions have been considered. Furthermore, there has to be a list of participants in an audit report (Meredith & Mantel, 2012).

Another major part of the risk control process is establishing a change management system. It is commonplace that the project will not materialize the way you originally planned it. There are many sources and causes of changes that possibly could affect your project and its course. Usually one could categorize these changes into one of the following categories

❖ Changes in Scope

❖ Implementation of contingency plans

❖ Improvement changes by project team members

All changes usually represent big challenges to the whole team and project manager. Often changes to the project are not avoidable and therefore a well-defined change review and control process in the early stages of a project is required. These control process include reporting, controlling and recording changes to the baseline of the project (Meredith & Mantel, 2012).

Most change control systems are designed to fulfill the following criteria

- Identify proposed changes
- List expected effects of proposed changes on schedule and budget
- Review, evaluate, and approve or refuse changes formally
- Negotiate and resolve conflicts of change, conditions and cost
- Communicate changes to parties affected
- Assign responsibility for implementing change
- Adjust master schedule and budget
- Track all changes that are to be implemented

Every accepted change must be integrated into the plan of record through changes in the WBS (work breakdown structure) and baseline schedule. The plan of record is the current reference in terms of schedule, costs and scope. If the change control system is not integrated with the WBS and baseline, sooner or later the project plan and control system will become unworkable. The key success factor for the change control system is to document every single change occurring. Benefits of these requirements are

- Inconsequential changes are discouraged by the formal process
- Costs of changes are maintained in a log
- Integrity of the WBS and performance measures is maintained
- Allocation and use of budget and management reserve funds are tracked
- Responsibility for implementation is clarified
- Effect of changes is visible to all parties involved
- Implementation of change is monitored
- Scope changes will be quickly reflected in baseline and performance measures

Change control is an important part of the project. As the project matures there must be a person or group who is responsible for approving the changes, keeping the documents updated, and communicating all changes to the relevant stakeholders. Success depends heavily on keeping the change control process updated.

Use of MS-Project Software for Project Planning and Monitoring, GIS

The Project Managers have a hard time monitoring the projects between site and office. The traditional approach for scheduling and progress control techniques such as bar charts and the critical path method are still being used by the project managers for planning which a serious disadvantage for the decision is making purpose as the spatial aspects fail to provide the required information. There is pressure on the project managers to shorten the delivery times and thus the current scheduling and progress reporting practices are in need of substantial improvements in quality and efficiency. Integration of Geographical Information System (GIS) and project management software's with visualization was recognized as one of the most important tools for achieving this goal. It should be seen perception of a project as well as in the integration of other parties' activities in the planning process. Furthermore, in large scale projects, a visual representation of the schedule can be extended to monitoring (Meredith & Mantel, 2012).

The application of geographic information system in project management will be new in the Indian project industry. GIS will allow construction managers and different people involved in project with different backgrounds to get the information about the progress of the project and support Decision Making. GIS will provide a common basis of understanding and communication among these people. Many people think of GIS as a presentation tool. A GIS does in fact create high quality maps that communicate considerable amounts of information in an efficient and attention-getting manner. GIS is both a database system with specific capabilities for spatially referenced data, as well as a set of operations for working with the data

This helps in saving time and resources and provides better client satisfaction. The construction industries strive for being on schedule, and cater to the needs of the population. To deliver the project on time, they need to be very fast, track information as and when required, manage the labor and also minimize wastage. The GIS application helps to achieve all such requirements with ease while acting as a central data system for all the data. Since the data can be used and integrated universally, it will allow future surveys or constructions' data to be merged with the existing ones, which in turn acts as a reference system. Therefore, the process of fabrication of a new infrastructure in a GIS would be much more efficient throughout the engineering process and can supply a serviceable management system that could cost a lot more otherwise.

Geographic Information System, referred to as GIS, can be defined as a set of tools for storing and retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes (Burrough, 1986). The ability of GIS to handle spatial data makes it a special category of information system. A GIS consists of four components, computer hardware, software, geographic data, and person and is designed to effectively capture, store, retrieve, update, manipulate, analyze, and display all forms of geographically referenced information. The GIS has already gained momentum in India. During the 15th Census of India, Census 2011; GIS based thematic maps were produced for various information like Demography, Economic Activity, Housing, Urbanization etc., which allowed the data collected to be error free. The Karnataka State Natural Disaster Monitoring Centre (KSNDMC) decided to adopt the ArcGIS Server technology to power their GIS portal for Disaster Monitoring. As the realtime collection, modeling and dissemination of disaster related information is of utmost importance, KSNDMC decided to establish a Web-GIS based Disaster Monitoring portal. Municipal Corporation of Greater Mumbai (MCGM), the primary agency for urban governance in Mumbai, India, has selected ESRI ArcGIS Server technology as its citywide geographic information system (GIS) enterprise management solution. ArcGIS Server will integrate images, detailed maps, and property-level maps and link them to a wide range of enterprise data used for various city functions (Meredith & Mantel, 2012).

Summary

After having read this chapter you have now likely gained a basic understanding of what risk management is and how it works. The conclusion must be Undertake Risk Management!

It has nearly only benefits. The effort involved in creating a well-defined and well-running risk management system is enormous, but the price is definitely worth paying.

If the project manager and all relevant stakeholders undertake risk management it will add value to each single activity and therefore to the whole project. Improvements are

- ❖ Provides a framework for the whole project in which activities happen in a consistent and controlled way
- ❖ Improves the decision-making process, supports the planning process and prioritisation of each activity by having a complete understanding off all project-related activities and project opportunities and threats
- ❖ Reducing uncertainty within the project
- ❖ Securing or even increasing assets of the company
- ❖ Optimising operational efficiency
- ❖ Developing and supporting the organization's knowledge base

Never forget risk management is an ongoing process and many project managers learn their lesson the hard way. Remember, risk never sleeps.

Case studies on Project Management Practices

INFOSYS LTD, Bangalore

Infosys has been well recognised as the representative of the 21st Century Indian software giant operating across geographies, working in a plethora of technologies, employing and managing large scale talent in many countries and delivering continued value to its customers who seem to be growing every day. Success at Infosys is largely credited to its high success rate in project delivery across the Globe. Hence it was an appropriate case for deeper study of project management practices in IT sector.

This study was intended to understand the Project Management practices at Infosys. A detailed meeting/interview with Project Director - EAS helped us to understand various project management attributes practiced by them, consolidated responses from PD - EAS is as follows

Project Organization

Project Organization in Infosys is as shown in the chart below. Infosys uses matrix structure of project Organization. Project organization structure is specifically designed to manage complex projects to ensure its successful conclusion and also to meet the requirements defined in the project brief. This structure enables channels of communication to decision-making forums and is backed up by job definitions which specify the responsibilities, goals and limits of authority, relationships, skills, knowledge and experience required for all roles in the project organization.

Project Board

The Project Board is the forum where senior management representatives of the Customer and Infosys come together to make decisions and commitments to the project. It consists of 2 roles namely Project Executive and Customer's IT & Management team.lt is therefore a very small manageable group of senior managers capable to make decisions on behalf of their organizations / interests without referring back to those organizations whilst working within the charter of the Project Plan. The Executive is ultimately responsible for the project and has to ensure that the project represents good value for money and balancing the needs of the business, user and supplier (all stake holders).

The Customer team represents the people who will use the final product - those who must specify the requirements of the end product.

Project Details

Enterprise Application Service (EAS) division at Infosys executes implementation projects of ORACLE products, SAP products for their customers worth ranging from 3 to 5 crores consuming more than 1.5 years of time with 40 people in each EAS project including onshore team. The complexity of project in functional interfaces definition and provides clearance for detailed design document.

- Critical Design Review This stage of review is to provide final approval for designs, specifications, baseline production, and Interface definitions and for finalizing detailed test plans.
- Test Readiness Review This review is to ensure compliance of activities to the design norms and programme plan before subjecting system for final testing.
- System Readiness ReviewReview of the detailed &fmal investigation of project deliverable happens at this stage. It is actually delivered for assembling with principal project (programme objective), detailed interface performance checks, certifying system

performance meeting requirements, Finalizing the system configuration and approval for system commissioning all these things happens at this stage of techno-managerial review mechanism.

Project Communication

ISRO clearly recognize the importance of timely flow of communication among programme participants is key for success in programme management. In order to achieve this ISRO has clearly defined and documented process flow for project communication, chart 4.11 below is quite self-explanatory in nature which depicts the flow of communication and responsible person at every stage of communication flow.

Every EAS project is developed simultaneously both at client place & Infosys campus. For clients abroad a small sized project team is assigned to work at client site.

EAS projects at Infosys is being implemented by following self-developed standards and guidelines like AIM(Application implementation methodology) Oracle E-business Suite, INTERACT, DART(Time Tracking tool),ALCON(Resource allocation),INFLUX(Business Process), PRISM Project Reviews by Infosys Senior Management (progress review), for feature development EAS team uses waterfall model, iterative model. These self-developed models cover activity planning, communication planning, progress tracking, risks identification & handling, Change Management etc.

Process followed

Programme Manager & Delivery Managers assisted by consultants takes care of technical & functional requirements of clients and they are responsible for project release & handover, business factors and project sign-off as well. Delivery manager takes care and ensure the timely release of project with the assistance of account manager & project manager. PO structure is matrix because PgM, DM, AM, PjM are responsible for many projects at a time. DM & team at onshore have constant interaction with DM & team at offshore through consultants to ensure timely & effective configuration, development and implementation of project.

Project Managers both at offshore and onshore handles multiple (typically 3-4) project teams assisted by respective team leaders. Onshore project teams are comparatively small in size than offshore team, due to various commercial reasons. Development stage involves PjM, Project team & consultants where they work towards giving shape & form to elicited technical & functional requirements. Consultants work closely with development team to ensure the meeting of client requirements. This process is followed by various testing procedure like SIT (system integration testing), UAT (user acceptance testing) to make software bug free. Before signing off or handing over of project/software, it is subjected to various trail runs to check & rectify the probable error that occur during full fledge operation, once it is achieved the software is finally is checked for precision in GO-LIVE testing process in this process software is tested imagining that it is used by clients, various dummy actions & counter actions are made to see the possibility of faults, misuse, errors etc due to end user usage simultaneously effort is also put on calculating the lead time required to solve customer operational issues with the software.

Key Elements of Project Process identified by Infosys are

*Traceability*Traceability ensures all Requirements are implemented in design, code,testing, and helps to identify impacted programs/documents in case of any change. It keep maintain reference between Requirement Number, Description, HLD Reference, DD Reference, Unit Test Plan Reference, Integration Test Plan Reference, System Test Plan Reference. Both forward and backward traceability exists. Forward traceability ensures all requirements are incorporated into product. Backward traceability ensures no unnecessary functionality is included unless specifically called for by a requirement.

*Defect Detection, Prevention, and Tracking*Defect Detection includes Reviews andTesting, which are common technique in project management. For Defect Prevention, Infosys suggests Learning from past projects, doing defect prevention regularly, and measuring the improvement. In Defect Tracking, it is ensured that all defects are closed.

Measures & Metrics'. Measures are rooted in scientific principles and give numericmeaning to physical attributes. And metrics are derived or proposed measures that cannot be directly observed, which provides insight into process or product quality characteristics. At Infosys, Measures are also called Basic Metrics, which include effort, defects, size, and schedule. Metrics are referred to as Derived Metrics, which include Process Metrics, Product Metrics, and Service Metrics. Metrics are used for setting quantifiable goals, measuring and tracking progress, taking decisions, and planning improvements. For metrics, accurate data is important.

Estimation Estimation is based on history data. Using RFP and requirement SPECcan estimate Size. Basing size, using Productivity, Skill Requirements, Execution Complexity, Risks/Uncertainties can estimate Effort. Basing Effort, using Resource availability, Dependencies/Constraints can estimate Time and Schedule. With Time and Schedule, Unit Costs, Costs can be estimated.

*Quality Assurance & Quality Control*Quality Assurance focuses on process. Itensures that Project Management Plan is followed. It also defines the project process through the project plan. Besides, it does Technology and Business domain training, and does audits.

Quality Control focuses on Product It measures a product against the existence of arequired attribute. Major QC activity is identifying defects (Reviews, Testing) and correcting them (Rework).

Project Risk Management At Infosys, a detailed plan for risk identification, monitoring and mitigation is a part of project planning. It covers risk identification, prioritization and mitigation options. Their business continuity plans are focused on Infrastructure, Security, Confidentiality and Privacy, People.

Process Infrastructure

Process Infrastructure includes the introduction of the implementation support of project management. These Process Infrastructures are PRIDE (Process Repository at Infosys for Driving Excellence), Quality System Documentation (QSD), Body of Knowledge (BOK), Process Assets, Process Database (PDB), Process Capability Baseline (PCB), and Tools Repository

Project Communication

Planned Communication is being opted to have frequent interaction with all project participants. Communication plan focuses on content, format, timings, sender & receiver. Communiques also contains project progress as and when requires.

Change Management

Change Management is an integral part of EAS project plan for which Infosys has separate methodology to handle it usually involves technical & functional consultants for respective change requirements. Account manager, Delivery Manager &Programme Manager all together takes care of business change requirements & other obligatory issues. EAS at Infosys encounters project scope change at higher frequency which is very common in IT industry with other factors like time, cost & quality freeze.

Reasons for deficient deliverables

Main reasons for deficient deliverables which are uncommon at Infosys as noted by project managers are,

- Estimation (Effort / technology errors),
- Resource and skills inadequacies,
- Proactive methods and foresight to identify risks to the project

Analysis

Infosys is one of the largest businesses in India with a turnover in excess of $4 billion in 2008. The company specializes in Information Technology (IT) and consulting. N.R. Narayana Murthy and six others started the company in 1981, and it is now the largest IT Company in India with its headquarters in Bangalore (although it was started in Pune). It employs more than 90,000 IT professionals and was famously rated Best Employer in India. It operates in a number of business sectors from banking to retail, and its services tend to encompass end-to-end IT solutions which includes a whole bundle of added-value solutions from infrastructure to software engineering.

Since the company is based in India its competitive advantage is enhanced. The Indian economy, despite weak economic indicators such as relatively high rates of inflation, has low labour costs. The workforce has relatively high skills levels in Information Technology. Couple these two elements together and you have an operational basis that offers low-cost based, highly skilled competitive advantage. Trained Indian personnel often speak very good English and are sensitive to Western culture, underpinned by India's colonial past. Infosys is in a strong financial position. The business turned over more than $4 billion in 2008. This means that it has the capital to expand, and also the basis to leverage potential investors. The company has bases in 44 global development centres, most of which are located in India, although the company has offices in many developed and developing nations. This means not only that Infosys is becoming a global brand but also that it has the capability to support the global operations of multinational clients.

Project Management is at the centre of the business at Infosys as service delivery is the key to company's growth and performance. Hence the company has invested very heavily into people, process and technology. Hiring the right people, training and motivating them are key differentiators for the successful delivery model both on site and off site locations. Process perfections come from following religiously six sigma projects, regular review mechanisms, issue and risk management methodologies. Technology has always been an enabler as the company and its employees are in the fore front of technology and have no qualms in accepting the same. Infosys is proud of using their own self developed methods & tools in project management and are striving to use & implement this more religiously.

In spite of all the great achievements, still in a few occasions deadlines fail and customers do get annoyed as a result of over dependence on process, lack of creativity and pro activity among employees that essentially comes from reducing all the activities in the project into mundane activities leading to frustrations, employee turnover and other related HR issues.

Conclusion

This case study proved that the age old management concepts of mutual trust, belief in self, team work can produce results even in today’s complex situations. Out of the box thinking, professional approach to the problem and proper planning brought the desired results. Focused approaches to problem resolution and persistent efforts have delivered the results. Project Managers believe they could have done better if they had applied more patience at times. It is worthwhile to note that without top managements understanding and support this would have not been possible. Generating agreements between all members of the team is necessary to keep the team motivated and moving. A leader’s role is critical to the success of the project team. Leading from the front & living by examples communicates a lot to the team and instils confidence in the leader. Finally Infoscians always believe honesty and hard work pays.

Chapter 5- Project Completion

Objectives

- To understand project auditing
- To understand team project close out and project termination
- To understand project follow up

Structure

5.1 Project Close-out

5.2 Steps for closing project

5.3 Project Termination

5.4 Project Follow-up

5.5 Project auditing

5.6 Case study

To Do Activities

1. List and briefly describe the ways projects may be terminated
2. Discuss the impacts, both positive and negative, of the termination on project team members. How might be negative impact be lessened.
3. Explain impact of project termination
4. Explain motives of project audit.
5. Discuss the various types of project audit
6. Why project follow up is so important?
7. Discuss Project close out.
8. Make a report of any two organizations in which projects are terminated abruptly. List out the causes.
9. Prepare questionnaires and take a survey of factors which can improve next project.
10. Make a report on implementation of project management principles in waste management.

5.1 Project Close out

The project closing is the last process of all project processes and the most often neglected one. Project closure is more than packing things up and starting to move right into planning the next project (Passenheim, 2009). The closing process consists of two sub-processes

1. Contract closeout
2. Administrative closure.

The contract closeout process is performed and completed before the administrative closure process begins. Both processes are concerned with verifying that the work of the project was completed correctly and to the stakeholders' satisfaction. One of the most important functions of this process is obtaining formal acceptance of the product of the project from stakeholders and customers (Passenheim, 2009).

The goal of closing is to get an official sign-off from the stakeholders acknowledging acceptance of the product and to file this with the project documents.

After delivering a successful project to the customers and stakeholders the project must come to an end. For this, a successful end has to be defined. Delivering only the product or service of the project doesn't mean it's been completed satisfactorily. It has to meet or exceed the stakeholders' expectations. These expectations and the project end are reached by documenting the acceptance of the product of the project with a formal sign-off and filing it with records for the future reference during the closing process.

Characteristics of Closing

A few general characteristics concern all projects during the closing process. During the closing, the probability of completing the project is at its highest and the risk is at its lowest. The major part of the work of the project is done and so the probability of completing is very high. Furthermore, the probability of not finishing the project is very low if not all of the work is completed during this process (PMBOK Guide, 2013).

There are several different reasons why projects can come to an end. In the best case the project has been completed successfully instead of being cancelled before completion.

A "normal" completed project is simply the most common circumstance for project closure. The finish of a project, such as building a new facility, is marked by the transfer of ownership to the customer. In other projects, the end can be marked by handing out the final design to the production department, the creation of a new product or the output is incorporated into ongoing operations.

"Premature" project closure describes the finishing of a project while some parts of the project have been eliminated. This can occur by the pressure put on the organization to finish a project or product because of, for example, the market situation. The risks and implications associated with this decision should be reviewed carefully and assessed by all stakeholders and the management.

Contrary to this, perpetual project closing describes the circumstance in which some projects develop a life of their own because they never seem to end. This phenomenon is not only caused by delays. Often the major characteristic is constant add-ons to the project. The customer continuously requires small changes that will improve the project outcome. These changes represent add-ons perceived as being part of the original project intent like adding features to software or to product design. The constant add-ons are typically to indicate poor definition of the project scope but the phenomenon can be reduced by the clear definition of project scope and limitations (Merdith& Mantel, 2012).

Audit groups or project managers have several alternatives available for projects displaying characteristics of becoming perpetual. They can limit resources, budget or time and redefine the project end or scope to force the closure. These alternatives should be designed to bring the project to an end as quickly as possible in order to limit additional costs and gain the positive benefits of a completed project (PMBOK Guide, 2013).

Of course, some projects simply fail but this circumstance is rarer. In practice, it is possible that the planned project is not realizable. Developing a prototype of a new product or technology can show that the original concept will be unworkable. Another example can be the developing of a new pharmaceutical drug. The project may need to be canceled because of unsustainable side effects.

The reflection of changes in organizational direction is important to the project team because this change can have a big effect. Normally the changes are small over a long period of time but sometimes major shifts in an organization require dramatic shifts in priority. In this change period, projects in process may need to be modified or cancelled. A project can start with a high priority but maybe crash during its project life cycle as conditions change (PMBOK Guide, 2013).

Contract Closeout

The Contract closeout process is concerned with completing and settling the terms of the contract. It also determines if the work described in the contract was completed accurately and satisfactorily. This process is called product verification. The product verification performed during the closing process determines if all of the work of the project was completed correctly and satisfactorily according to stakeholder expectations (Passenheim, 2009).

Contract closeout also updates records and archives the information for future reference. These records detail the final results of the work of the project. Sometimes contracts have specific conditions or terms for completion and closeout. These terms or conditions should be made known to all parties involved so that project closure isn't postponed because of missing an important detail. The project team has to know if there are any special terms so as to prevent an accidental delay in the contract or project closure (Passenheim, 2009).

The contract closeout has one input and one tool and technique. The input to this process is contract documentation. This includes the contract itself and all the supporting documents that belong to the contract. These attachments could be documents like the work breakdown structure, the project schedule, change control documents, technical documents, financial and payment records and quality control inspection results. All information gathered during the project are filed once the project is closed out so that anyone considering a future project of similar scope can reference what was already done.

One of the purposes of the contract closeout process is to provide formal notice to the seller, usually in written form, that the contract is complete. The project manager has to document the formal acceptance of the contract. Often the provisions for formalising acceptance of the product and closing the contract are spelled out in the contract itself.

If an extra procurement department exists which handles the contract administration, that department will be expected to inform the project management when the contract is completed and will in turn follow the formal procedures to let the seller know the contract is complete. The contract completion should then be noted in the copy of the project records.

This process is the organizational way of formally accepting the product of the project from the vendor and closing out the contract. If the product or service does not meet expectations, the vendor will need to correct any problems before a formal acceptance notice is issued. Normally quality audits are performed during the course of the project and the vendor is given the opportunity to make corrections earlier in the process than at the closing stage. To avoid any problem it is wrong to wait until the very end of the project and then spring all the problems and issues on the vendor at that time. It's much more efficient to discuss each problem with a vendor as it appears as this provides the vendor with the opportunity to correct them as and when they occur (Merdith& Mantel, 2012).

Formal acceptance and closure is one of the outputs of the contract closeout process. The other output is called the contract file. This is simply all the contract records and supporting documents. These records are indexed for easy reference and included as inputs to the administrative closure process. Then, at the conclusion of administrative closure, project archives, which include the contract records, are filed for future reference (Merdith& Mantel, 2012).

Administrative Closure

The key activity of the administrative closure process is concerned with gathering and disseminating information to formalise project closure. Every project requires closure and the completion of each project phase requires administrative closure as well. Administrative closure shouldn't wait until project completion but rather should be performed at the end of every phase (Passenheim, 2009).

Administrative closure verifies and documents the project outcomes just like the contract closeout process. It is important to know that not all projects are performed under contract but all projects require an administrative closure.

Since verification and documentation of the project outcomes occur in both processes, projects that are performed under contract need to have project results verified only once. When the project outcomes are documented, formal acceptance is requested of the stakeholders.

The Administrative closure process gathers all the project records and verifies that they are up to date and accurate. The project records must correctly identify the final specifications of the product or service the project sent out to produce. Administrative closure is in place to ensure this information accurately reflects the true results of the project (Passenheim, 2009). The three inputs to this process are performance measurement documents, product documentation and other records which are related to the project.

All of the performance measurements that were used to analyse project progress during the controlling processes are included as part of the documentation for the administrative closure process. Any document that helped establish the basis for the performance measurements, like the project plan, the cost budget, cost estimates and the project schedule are also collected here. Finally, these documents are reviewed to make certain the goals and objectives of the project were met successfully. Each of these documents should be available for review during the administrative closure process. According to the formal acceptance of the project by the stakeholders, the executive management team or the customer may request to see this document (Merdith& Mantel, 2012).

The second input of administrative closure is product documentation. This documentation includes anything that details the product or service of the project. This details things like the requirements documents, specifications, plans, technical documents, electronic files and drawings. The input includes all information that details or lists the product specifications or requirements. Also these documents should be available for review such as the performance documents (Passenheim, 2009).

Of course, it is possible that projects work very well and without any problems he project just falls into place according to the plan, the team functions at the performance stage and the customers and stakeholders are happy. It will be difficult to close these projects because they have progressed particularly well and still work. The majority of projects can fall into this category if the team practice good project management techniques and exercise those great communication skills (Merdith& Mantel, 2012).

5.2 Steps in Project Close Out

At the end, the last outputs of the last process of your project will be the

- Project archives,
- Project closure & formal acceptance and
- Lessons learned.

Project Archives

When all the work of the project is completed, the vendor is paid, the contract is closed, and the records are gathered and project archives will be created. These include any project documents completed during the project. All of the inputs to this process are included here as well as the contract documents. Keep in mind that if projects are performed under contract, the archiving of financial records is especially important. These records may need to be accessed if there are payment disputes (Passenheim, 2009).

Furthermore, this information is especially useful when estimating future projects. Projects with large financial expenditures also require particular attention to the archiving of financial records for the same reasons. All of these documents should indexed for reference and filed in a safe place. They will include electronic databases and electronic documents as part of the project archives as well. These records can be stored on a network drive or copied onto a CD that's kept with the project binder. The organizational policies will dictate how the project records should be filed. If no policies exist, they have to be created (Passenheim, 2009).

Project Closure and Formal Acceptance

The project closure output concerns verifying that the product of the project meets all requirements and obtains formal sign-off of the acceptance of the product. Formal acceptance also includes distributing notice of the acceptance of the product or service of the project by the stakeholders and customers. Documenting formal acceptance is important because it signals the official closure of the project and it confirms that the project was completed satisfactorily. In this form, a document for sign-off indicates that the signing person accepts the product of the project.

Another important function of sign-off is that it signifies the beginning of the warranty period. The warranty of work for a time period after completing a project is often used in projects that produce software programs. Typically, in the case of software projects, bugs are fixed for free during the warranty period. In this case, the critical point is that the warranty that has to indicate exactly what is covered (Merdith& Mantel, 2012).

Lessons Learned

The purpose of lessons learned is the same as the processes before but they document the successes and failures of the project, too. As an example, lessons learned documents the reasons why specific corrective actions were taken, unplanned risks that occurred, mistakes that were made and could have been avoided.

There are facts that can be learned from failed projects as well as successful projects and this information, whether good or bad, should be documented for future reference. Often this work is not done because a lot of employees don't want to admit to making mistakes or learning from mistakes made during the project. It could be disagreeable to associate their name with failed projects or even mistakes (Passenheim, 2009).

Organizations that do not document lessons learned probably do conduct post-implementation audits. Documenting and gathering information during this procedure can serve the same function as lessons learned if they include the good and the bad alike. Post-implementation audits aren't an official output, but they go hand in hand with lessons learned as they examine the project from beginning to end and look at what went right and what went wrong.

At the conclusion of the project the team members will be released and return to their functional managers or new projects. This release is a non-official process but it should be noted at the end of the project. When the project is getting closer to completion the managers should be informed what the schedule looks like so that they can start planning activities and scheduling activity dates (Passenheim, 2009).

5.3 Project Termination

When hearing the term „project termination" most people think about the termination of a project caused by failure. But the term is not dependent upon the success of the project. It also happens that a successful project can end earlier than originally planned. But for most people the word "termination" has a negative meaning. This abstract will focus more on reasons and problems of termination than on the "normal" closure phase. Sometimes the term "termination" is used as an equivalent for "project closure". Another word is "close-out", also used as an equivalent. The term termination is used for an ending of a project before it was planned. If a project ends in the planned time it is mostly called project closure. Close-out in literature is often used as an "umbrella term"(Merdith& Mantel, 2012).

Reasons for Termination

Termination of a project is predictable, but how is it terminated and when? It may have a deep and long lasting impact on the organization and its employees. The success of projects to come may depend not only on the success of past ones, but also on how unsuccessful projects are treated by the organization and its stakeholders. Companies have the option of initiating various corporate projects with varying degrees of risk. If an organization chooses to accept greater risks, it should avoid disciplining members of projects that turn out to be unsuccessful. If team members believe they will be punished for participating in beeing a member unsuccessful projects, they might be less willing to terminate failed projects and may become unwilling to take a risk(Passenheim, 2009).

External and internal factors that influence the success or failure of projects will be identified and clustered. The importance of each factor identified varies by organization and project type. Organising the termination process is in particular important when it has failed, because of the long-standing impact on future projects as well as the organization's image. Including project team members in the termination process will increase their commitment and loyalty, especially to the organization and to future projects. A post-audit report will be prepared at the end of a project that summarises the project and provides recommendations on possible project approaches for similar tasks in the future. In a final step, as a project is terminated or completed it is important that senior management recognises and rewards the contributions of the project team (Passenheim, 2009).

Several factors have direct influences on the usability of a planned or running project. All factors usually fall into one of the following categories. During the life of a project, the steering committee and the project management must examine these critical factors continually to ensure that it can still realise the initially set goals.[iii]

Technology

The technological track of the project can have a major influence on its chance of success. steering committee and the project management must be able to value the technological path so that they can

a) measure the progress of the project;

b) have a general idea of when breakthroughs can be expected;

c) not become disappointed when the rapidity of development appears slow.

Organization

Organizational factors that can influence the practicability of a project include internal competition, executive support and the company's strategy. Internal competition, especially in critical situations like access to important funding or resources, will affect the project team's motivation. Also, as the number of projects increases, the more likely it is that one of them will end in failure. Maintaining management's support in some projects is likely to be the single most important factor in influencing the success or failure of a project. Another factor extremely important is the compatibility of the project with the corporation's strategy. A project that no longer fits with the organization's objectives is usually dedicated to be terminated.

Market Forces

The competition has a strong influence on the viability of new or planned projects. The value of a project can be reduced by the sudden availability of alternatives or competing technological innovations. Continuing to fund an outdated project can be avoided by maintaining communication between the marketing, manufacturing, and R&D departments (Passenheim, 2009).

Planning

Naturally, the firm's ability to manage a project will have a significant impact on its eventual success or failure. Central to this, of course, is the project plan, which should be exceptionally detailed. Difficulties which could threaten the schedule must be identified so that workable alternatives can be developed ahead of time. There will always be a basic, inherent level of uncertainty in every project; however, thorough planning can reduce most of these risks to an acceptable level. It is also important to note that the quality and level of planning for a project is frequently related to the level of experience of the project team. More experienced project teams tend to plan and organise more effectively (Passenheim, 2009).

The Project Team

As would be expected, the team plays a key role in the project's success or failure. The effectiveness of a team is, in turn, governed by the abilities of its project manager, the team's overall commitment and enthusiasm, and the co-operation of the team as a whole. That means the role of the project manager is the most critical. He or she must be able to co-ordinate changing activities, resolve conflicts, and keep management informed and committed to the project - while also keeping the project on track. The project team should also be relatively stable. Changing important team members at critical stages in the schedule can have a fatal effect. On the other hand, a new team member, if briefed properly, can provide a fresh approach to many problems (Passenheim, 2009).

Economic Factors

These factors may have a significant influence on the project's ability to generate a minimum acceptable return on the organization's investment. While financial measures, such as return on investment (ROI), are not the only factors influencing success or failure, they do provide a measurement tool for evaluation. It is entirely possible that a project, which is on schedule and well within its budget, may be cancelled because of unrelated financial constraints dictated by the organization. When firms fail to achieve their desired level of profitability, they always have the option to re-evaluate ongoing projects and terminate those that are less viable or overly expensive (Passenheim, 2009).

Other

Miscellaneous factors that influence the success or failure of a project include new government regulations, problems with patent ownership, or new environmental concerns.

The key, of course, is being able to recognise if and when projects start to fail. To do this requires maintaining a feedback loop throughout the project cycle. And the effectiveness of the feedback loop depends upon a constant flow of quality information among the project manager, team members, the customer, and senior management (Merdith& Mantel, 2012).

Types of Project Termination

There are two types of project termination – "natural termination" and "unnatural termination". "Natural termination" reflects the fact that the aims of the project objective have been attained. "Unnatural termination" means that work on the project has stopped because the project constraints have been violated or the project objective has become irrelevant to the overall goals. There are four common ways for terminating a project (Passenheim, 2009)

1. Extinction
2. Addition
3. Integration
4. Starvation

The following are the most likely reasons for which a project may be terminated

By Extinction

- The project has successfully completed the planned scope and the client has accepted it.
- It has been superseded by the external developments like technological advancement, market crisis etc.
- It has failed to achieve its goal.
- It no longer has the support of senior management.

By Addition

Termination by addition occurs when the project team becomes a new part of the parent organization. Resources are transferred to the new organizational unit, which is integrated into the parent organization. This type of project termination is typical for organizations with a project structure.

By Integration

The project is successfully completed. The project product is integrated into the operations of the client. This is the most common mode and most complex operation. Termination by integration occurs when the project's resources, as well as its deliverables, are integrated into the parent organization's various units. This approach is very common in a matrix organization because most people involved in a project are also affiliated with one or more functional units. When the project terminates, team members are reintegrated into their corresponding units (Passenheim, 2009).

By Starvation

- The project is terminated by budget decrement.
- It is also known as withdrawal of "life support".
- The reason for this termination is generally to shadow the failure to accomplish the goals. This can save face for the senior management and avoid embarrassment.

Senior management is responsible for the decision to terminate. Before making a decision senior management should work closely with the project manager who is in charge of the project. The project manager should know the situation quite well. If he is a good project manager he works closely with the project team and gets periodic feedback. So he should be able to give the management advice whether the project should be terminated or not.

There are also other "measurement methods" with which to decide if the project should be terminated or not. Before terminating, a final audit could verify the results to give senior management another source of advice (Merdith& Mantel, 2012).

Project Termination Problems

There are some problems caused by project termination. These can be divided into two groups. The first group covers the emotional problems. These problems can be divided again into two parts, problems with the staff and problems with the client. The staff might be afraid that they won't have future work. Project termination can also lead to some losses, for example loss of interest in the remaining task, loss of project- derived motivation or the loss of the team identity. You also might have some trouble with reassignment. Which people will be put together in which project?

On the other hand there is the client. After a termination he might change his attitude, lose interest in the project, or won't ask the organization to take part in further projects. It also might be that the client will change his personnel knowing that the project has already failed, the client might decide that people who worked on the project should change their position. This could lead to unavailability of key personnel (Passenheim, 2009).

The second group deals with physical problems. This group can also be divided into two smaller ones as shown in Fig. 5-1.

Internal Problems

- Certification needs
- Identfication of remaining deleiverables
- Identification of outstanding commitments
- Control of charges to Project
- Screening of Partially completed tasks
- Closure of work orders
- Identifiaction of facilities to Project
- Accumulation and structring of historical data
- Disposal of unused matarial

External Problems

- Agreeement with clinet with remaining deleverables
- Obating required certification
- Agrrement with suppliers on outstanding commitments
- Comminiacting closure
- Closing down facilities
- Determination of requirements for audit tral data

Fig. 5.1 Impact of termination (Source: Passenheim, 2009).

There are also other "measurement methods" with which to decide if the project should be terminated or not. Before terminating, a final audit could verify the results to give senior management another source of advice.

A project may be cancelled for a variety of reasons, including lack of funding, technological obsolescence, changes in consumer trends, mergers and acquisitions, loss of the "champion", and negative cost/benefit relationships. Although the reasons may vary, the impact is frequently the same. Project cancellation can affect employee productivity, the reputation of the firm, and the value of the firm's stock. Although hardly any research on the topic of employee productivity and project cancellation has been done, experienece suggests that a project team's perception of the cancellation may influence their productivity for the next several years. However, there are guidelines to help soften the impact of cancellation on the team. To begin with, it is essential that the project team is included in the cancellation process and should be made aware of the rationale behind the cancellation well before the official announcement. Moreover, this rationale should be consistent with the perceptions of the project team (Passenheim, 2009).

A study found eight factors which influenced whether an employee perceived the cancellation of a project negatively

1. The rationale for cancellation.

2. Communication between management and the project team.

3. Careful planning for the cancellation process.

4. Strong management commitment and support for the project from its inception.

5. Effective planning and leadership of the project.

6. Prompt and comparable reassignment of project personnel.

7. Acknowledgment of the efforts of the project team.

8. Participation of the project team in the cancellation decision-making process.

As might be expected, the output and commitment of team members immediately before a project is cancelled, and for one or two months after the announcement, will be drastically reduced. This loss in productivity and commitment will be exacerbated if the project team perceives the cancellation negatively. Worse, the individual's commitment to the organization may depend upon his or her perception of the cancellation. Employees who view a cancellation in a more positive light will have higher levels of commitment than those who view it more negatively.

How a project is viewed within the organization is also very important. Because corporate resources can be very limited, projects that are perceived to be draining scarce resources tend to undercut morale. Other project teams envy the resources "squandered" on unproductive or failing projects. This, in turn, leads employees to question the wisdom of senior management, and reduces their productivity and level of commitment to the organization (Merdith& Mantel, 2012).

5.4 Project Follow-Up

Project Follow-up is a general process for controlling and monitoring status of project work to ensure that the project is performed on schedule, within budget and as per requirements. It uses feedback on costs, schedules, requirements, employee performance, and other critical factors to determine project success (Passenheim, 2009).

The key goal of the follow-up process is to monitor the course of a project and adjust project activities when needed to ensure effectiveness of project results. The process achieves this goal by performing the following 6 steps

1. Managing variances to confirm there is no uncontrolled change that causes project instability
2. Controlling scope to ensure the project is performed within accepted boundaries and requirements.
3. Monitoring spending to avoid cost overruns and budget failure
4. Responding to risks to keep the project feasible and effective
5. Assuring quality to ensure customer acceptance of deliverables
6. Controlling schedules to prevent delay and procrastination

The project follow-up process starts with the beginning of project activities, lasts throughout project implementation, and ends up with completion of project goals. Another name of this process is project delivery management. Follow-up can serve many purposes ranging from technical and scientific to socio-political and management aspects (Passenheim, 2009)

- Control of projects and their impact follow up provides both verifying and controlling functions for implemented projects.
- Maintain decision-making flexibility and promote an adaptive management approach feedback from follow-up programmes provides opportunities for project managers and regulatory agencies to respond when changes in an activity, in the environment or in the social-political context call for an adaptation of current practices.
- Improved scientific and [7758-technical knowledge] many activities involved in projects might be based on scientific methods. Some follow-up activities evaluate the utility and effectiveness of these tasks. Follow-up will allow the better understanding of new technologies and approaches, which may result in improving the quality of measures or techniques used in future projects.
- Improve public awareness and acceptance on-going follow-up programmes may improve public awareness about the actual effects of development projects, leading to improved public acceptance of proposals.

Follow-up (Supervision) Programme Design

Factsheet Block Body

1. Determination of Need and Scope

The question of why to conduct an internal follow-up programme for your project can be answered with a multitude of different solutions. The core purposes are control, information and communication. A follow-up programme will definitely add value to your project and future activities, and therefore it needs to be included during the planning step. It is indispensable that you and your team realise the need of it. In this step you should define the scope of the follow-up issues (what is to be supervised), specially the indicators that will help you to keep an eye on the project. For instance, if you installed a new wastewater treatment plant, you should monitor the quantity and quality of the treated water, as well as the level of satisfaction of the end-users, and take the necessary steps if there is scope for improvement.

2. Defining Tools, Methodology and Time-Plan

Once the scopes of the follow-up programme as well as the indicators are defined, the next step is to define the tools and methodologies you will need. This means the type of activities, such as visits to the project site, laboratory tests, interviews with the stakeholders and the frequency and time span of these activities

3. Financing the Follow-up Programme

Even though that most of the external financing programmes that support projects in the water and sanitation sector do not provide funds after the project termination, it is imperative to plan ahead how the costs of the post-implementation activities will be covered. One option is to cover the costs through beneficiaries' contribution, in case there is a component of cost-recovery through end-user's services. In this case, it is important that the services fees include external follow-up activities. Another option is to cover the costs of the mandays, laboratory tests, field visits with the overheads or the annual budget of the organization. Finally, you could include supervision of on-going projects as part of your new proposals, justifying the need for a follow-up component as part of the gathering knowledge experience.

4. Determination of Roles and Responsibilities

The most important issue to take care of is to assign completed projects to your staff members. It is essential to foment the sense of ownership among your team members, especially of those projects which are completed. Otherwise, the implemented projects will be forgotten when new ones start. Deliberately look out for monitoring and evaluation skills in all your project/programme and management positions, they will be of support in all these process (Merdith& Mantel, 2012).

5. Gathering Data and Evaluation

Once the project is completed, and the internal follow-up starts, make sure to plan and integrate the visits, communication with stakeholders, laboratory analysis, etc. in your day-to-day activities.

Unfortunately the evaluation of outcomes and results from the follow-up is often not conducted, but this analysis should be carried out as it is a critical step in the process. An analysis of the data collected should be conducted to ensure that the information provided is useful for the targeted audience. Overall, the evaluation stage needs to identify the lessons learned from the follow-up programme.

The evaluation stage of a follow-up programme may determine that further steps are needed in order to manage the problems identified. To remedy problems identified during follow-up, modifications of project design, activities, operation or maintenance activities might be required (Morrison-Saunders, 2004).

6. Reporting

To ensure that reporting of results is not neglected, it is recommended that a formal reporting and evaluation process be developed. In order to avoid extra work and allow for comparison, make sure to develop a simple template for all the members of the staff to report about their internal follow-up activities and the evaluation. The follow-up reports should include as a minimum (Passenheim, 2009)

- Short description of the project
- Location of the project
- Contact person in the project site (with contact information)
- Description of the follow-up mechanisms (e.g. field visit, lab test, etc.)
- Issues or problems identified
- Results
- Data analysis and evaluation
- Corrective measurements undertaken
- Further actions proposed to deal with the issue
- Lessons learned

Advantages of follow-up

- ❖ Managers and other stakeholders including donors need to know the extent to which their projects are meeting their objectives and leading to their desired effects
- ❖ Follow-up builds greater transparency and accountability in terms of use of project

resources

- ❖ Internal follow-up alerts managers to actual and potential project weaknesses, problems and shortcomings before it is too late
- ❖ Future planning and programme development is improved when guided by lessons learned from experience.
- ❖ Successful implemented projects serve as reference for future applications for funds
- ❖ In overall, it avoids that the implemented projects are forgotten with the time

Disadvantages of follow up

- ❖ Internal follow-up of projects require human power and extra activities, which are mostly not financed by the funding agency after the project completion
- ❖ To follow-up completed projects might deviate the attention and efforts of the members of the team working in new projects

5.5 Project Audit

An audit can be described as an evaluation of a person, organization, system, process, project or product. Audits are performed to ascertain the validity and reliability of information, and also provide an assessment of a system's internal control. The goal is to find out whether or not a project for example is “on time” or “out of budget”. It is also used to find out if the project meets its specifications and is often part of the quality management of a company. In general an audit is a tool to improve quality (Passenheim, 2009).

The audit may be a single occurrence or a repetitive activity, depending on the purpose and the results of the audit and the product/service, process, project or management system concerned. A properly conducted audit is a positive and constructive process accomplished by qualified personnel. Depending on the subject the “current status” is analysed, or a comparison with the actual targets is done. Often an audit is used to find unspecified problems or potential for possible improvements. It helps prevent problems through the identification of activities likely to create problems. Problems generally arise from the inefficiency or inadequacy of the activity concerned (Passenheim, 2009).

Audits play an important role during installation, certification and running of management systems as well as for the evaluation of projects. Audits can be distinguished by different criteria

By Subject

- Financial
- Information
- Exactness, Validation
- Compliance
- Performance
- Goal reaching
- Economic efficiency
- System audit
- Product audit
- Process audit
- Project audit
- Quality audit
- Environmental etc.

By Auditor

- Internal audit (1st Party)
- Supplier audit (2nd Party)
- Certification audit (3rd Party)

Others

- Audit in relation to the certification of management systems
- Pre-audit to determine the possibility of certification (a so-called “friendly audit”)
- Survey audit

Main Audit Types

Although many types of audits exist, basically all of them are based on one of three types. This distinction is made by the subject of the audit.

These three subjects are

1. Products (services),
2. Processes
3. Systems.

This leads to the basic audit distinction.

The Product Audit

The product audit examines a product or a service. In the case of a service the audit is called a service audit but the system is the same. The examined aspects in this audit are different attributes of the product. e.g. packing or conformity with the set standards.

The audit is made on the final product after the regular final inspection. This means the product is tested in the condition in which it would be delivered to the customer. So the audit can also include the evaluation of the logistics system which carries out the delivery. This audit type is more technical and could also include a destructive test of the product. The complete product characteristics should be examined. In addition to this, the audit should be made frequently (Passenheim, 2009).

The Process Audit

In this type of audit a single process is examined. Usually only one work crew is involved in the evaluation. The process audit is used to find out whether or not the process is within the time limits and conforms to the specifications. This could also include examinations of the process environment and all single parameters which are important to the process such as temperature, pressure or accuracy. As well as special processes like welding or examinations, the resources of the process and the inputs and outputs are tested. This type of audit can also be part of the system audit.

The System Audit

The subject of interest in a system audit is the management system. To evaluate a management system every action or decision which has an influence, for example, on the quality program of the company has to be documented. Furthermore, this audit takes a look at everything that is influenced by the management (this is also necessary to evaluate the decisions made). Therefore a system audit includes product and process audits as well as service audits and even looks at the company's internal departments such as purchasing or waste management (Passenheim, 2009).

Internal and External Audits

Another classification of audits is the distinction between internal and external Audits. Internal audits are "first-party" audits while external audits can be either "second-party" or "third-party".

The first-party audit is an internal audit. Its main attribute is that the auditors are employed by the examined company. It is important that the auditors are not concerned by the results of the audit. It is therefore useful that the auditors are part of a different department than the one examined. The reason for an internal audit is the measuring of weaknesses and strengths according to the company's own standards. This type of audit can also be outsourced. The advantage here is that the company's own workers can continue with their day-to-day business (Passenheim, 2009).

The second-party audit is more formal than the first-party audit. This is because it can have an influence on contracts (which this type of audit can be a part of) and on purchasing decisions. The audit is performed by external employees for example from the customer on a supplier. The evaluation itself takes into account the facilities, resources, personnel, etc. This audit is for example done before a contract is signed to ensure that the supplier is able to meet the requirements.

The main feature of the third-party audit type is the complete independence of the auditor. A third - party audit is performed by an external auditing company. As a result, no conflicts of interest can occur while an audit is performed. The goals of these audits are certifications, approvals or awards but also penalties or fines. As an example The government does mandatory audits on safety in relevant industries like nuclear plants (Passenheim, 2009).

Motives of an Audit

Auditing is part of the quality assurance function. It is important to ensure quality because it is used to compare actual conditions with requirements and to report those results to the management. Although audits are performed mostly to improve quality (with regard to the definition of the term "quality"), there are some concrete reasons to perform audits. The facts provided by an audit can be used to

- Provide input for management decisions, so that problems and costs can be prevented or rectified.
- Keep management informed of actual or potential risks.
- Identify areas of opportunity for continual improvement.
- Assess personnel training effectiveness and equipment capability.
- Provide visible management support of the quality, environment and safety programs.
- Ensure ongoing compliance with and conformity to regulations and standards.
- Determine system and process effectiveness.
- Identify system and process inefficiencies.
- Improving business performance.

Preparation and Costs

One of the most important steps concerning audits is the right preparation. The main step here is defining clear objectives. Examples for those objectives are

- Perform and present meaningfully (for the customer)
- Ensure regular performance of required audits and ensure frequent audits of critical functions
- Ensure that audits are performed only by trained, qualified, and independent auditors
- Promote a strong alliance between the audit function and the auditee
- Standardise the auditing process and form a basis against which to measure continual improvement of the audit program
- Support the objectives/strategies/goals of the organization
- Ensure project and operational safety and proper environmental stewardship
- Support management objectives for improving project performance

In addition to defining the objectives, an agenda is needed as well as a clear definition of the responsibilities. Also the reasons for the audit must be clear for everyone involved. A simple tool which helps in successful auditing is a set of seven questions that need to be asked before starting

1. Who performs and who participates in the audits?
2. What activity or system is being audited?
3. Where are the audits performed?
4. When are the audits performed?
5. Why are the audits performed?
6. What is the driving force behind the audit?
7. How is the audit performed?

Like every activity used to improve or measure a process, product or project, an audit generates costs. Those costs should be lower than the cost of the benefits. Although the benefits can’t be estimated exactly before the audit (often because of the “unclear” result) the costs can can be relatively clearly estimated (Passenheim, 2009).

The costs are

- The auditor's time spent preparing, performing, reporting, following up and closing the audit
- The Auditee's time spent participating in and following up on actions arising from the audit
- Overhead costs of materials, travel, accommodation, support staff and logistics

It should be mentioned that audit costs can rise enormously when performed by inappropriate personnel, meaning untrained auditors or people who are involved in the company or even in the examination process.

The reason for this is the inability of that person to give constructive analyses. In most such cases the result is only destructive critique.

As mentioned earlier, the audit is not a single operation. It is a tool to improve quality and quality can always be improved. So the idea of the audit cycle is that is is an ongoing process, which means that audits are performed from time to time. But audits should be connected to each other.

Improvement starts when the results are compared. Also, the auditors become more skilled and maybe find potential improvements they did not see earlier. The goals can also change after a while, maybe because of new technical achievements or simply because of an environmentally change. If goals are changed the whole audit process has a new basis and needs to be repeated (Passenheim, 2009)..

Summary

This chapter illustrated the necessity of different aspects of preparing and executing parts of the project management process. The audits are performed to ascertain the validity and reliability of information, and also to provide an assessment of a system's internal control. It gives any organization the chance to prove its excellence and therefore the chance to generate profits e.g. by getting a big contract with a new customer.

The termination and closure process shows the significance of ending a project efficiently and under cost control aspects. Also, the learning benefits, even from a terminated project, may help to improve further projects. Project closure is the most often neglected process of all the project management processes. The closure can be defined by four important aspects, which are

- Checking the work for completeness and accuracy.
- Documenting formal acceptance.
- Disseminating project closure information.
- Archiving records and lessons learned

The two processes in the closing group are contract closeout and administrative closure. Contract closeout is performed before administrative closure and is concerned with settling the contract and completing the contract according to its terms. Its two outputs are contract file and formal acceptance and closure.

Administrative closure is performed at the end of each phase of the project as well as at the end of the project. Administrative closure involves documenting formal acceptance and disseminating notice of acceptance to the stakeholders, customer and others. All documentation gathered during the project and collected during this process is archived and saved for reference purposes on future projects.

Lessons learned documents the successes and failures of the project. Many times lessons learned are not documented because staff members do not want to assign their names to project errors or failures.

Documenting these "learned from past" experiences can avoid the repetition of the same errors in new projects.

5.6 Case Study the Delhi Metro Project Efficient Project Management in Indian Public Sector (Source L. Sharma, 2015)

Introduction

With a 6.5 km section of Line3 becoming operational in April 2006, Phase I of the Delhi Metro project was nearing completion. Of the total length of 65.16 km of the first phase, 62 km had been completed and opened for service. This phase was set to cost Rs. 98 billion. As of early 2006, around 450,000 passengers were traveling by the Delhi Metro every day. The Delhi Metro was meant to solve Delhi's Traffic problems, which had become almost unmanageable. The first steps to build a metro system in the city were taken in the early 1990s. In 1995, the Government of India (GoI) and the Government of the National Capital Territory of Delhi (GNCTD) formed the Delhi Metro Rail Corporation Ltd (DMRC) under the Companies Act to construct the Delhi Metro.

Conceived as a social sector project, a significant portion of the project cost was funded through a soft loan provided by the Japanese government through Japan Bank International Corporation (JBIC)4. The rest was contributed by GoI and GNCTD through equity. With Phase I of the Delhi Metro project nearing completion, the GoI decided to extend the metro network and work on Phase II of the Delhi Metro project was set to commence in September 2006.

Metro Project

In order to implement the Delhi Metro project, the GoI and the GNCTD set up a 5050 joint venture company called the Delhi Metro Rail Corporation Ltd. (DMRC). The company was incorporated under the Companies Act in May 1995. The DMRC was to complete Phase I of the project within 10 years, i.e., by the end of 2005.

Funding the Project

Globally, most urban MRTS projects were financially unviable because the fares could not be fixed solely on a commercial basis. If the fares were fixed too high, the passenger numbers would remain low, thereby defeating the very purpose of setting up the system. Therefore, the concerned governments generally bore the capital costs of an MRTS system. In the case of the Delhi Metro project too, the GoI and the GNCTD bore the capital costs. The total cost of the first phase of the project was initially estimated at Rs. 60 billion, at April 1996 prices. Later in 2002, with the cost of the project rising by approximately 10% per year, the estimate was revised to Rs. 89.27 billion...

Project Team

With the funding for the project being finalized, the next step was to constitute a project team. Sreedharan was appointed as project manager and managing director of the DMRC in November 1997. A technocrat, he had had a long stint in the Indian Railways (IR) and had retired in 1990. During his service with IR, he had earned a reputation for completing major projects on time and within the budget...

Planning the Project

In India, major infrastructure projects are often stalled because of a lack of funds, political interference, lack of professionalism and accountability, property disputes, corruption, etc. Therefore, even before the commencement of the project, the DMRC attempted to put in place effective systems to ensure the smooth progress of the project. Funding was not an issue in the case of the Delhi Metro project because it was settled even before the project commenced.

Managing the Stakeholders in the Project

Effective project management involved not only completing the project on schedule and within the budget, but Also managing the project's stakeholders. The stakeholders included the governments, the contractors, the funding agencies, and the general public. Despite assurances that the DMRC would enjoy autonomy, it faced political pressure not only in its recruitment processes, promotions, and contract awarding but also in land acquisition...

Project Evaluation

The successful completion of the project effectively silenced the critics who had been skeptical about the ability of an Indian public sector organization to complete any project, let alone one as complex and costly as the Delhi Metro, on time and within the budget...

Project Implementation

The construction work on the project was commenced on October 1, 1998. The entire project was divided into three lines. Further, these lines were divided into sections Line 1 (Shahdara to Rithala). The work on Phase I commenced with the Shahdara- Tis Hazari section of Line 1, covering a distance of about eight kilometers. The work involved utility diversions, barricading, and actual civil construction. A major part of this section was on elevated tracks. All tracks in the elevated corridor were laid on concrete (ballastless). The tracks were supported on single piers.

Outlook

The Delhi Metro was expected to play a major role in relieving the transport problems faced by the city' residence. Moreover with the GOI planning extensions to the Metro, it appeared that the benefits of an efficient transport system would be enjoyed by the people living in a wider geographical area than originally planned.

Project Management in Organic Waste Recycling in Romania

Management strategies applicable to waste recycling in Romania

It is necessary to promote environmental management and a sustained campaign on sustainable development, so, to determine adoption of some good decisions, which lead to improved performance in this field. It is clear that strategies used, those have targeted, mainly just waste disposal, they did not lead to reduction of pollution and that it is necessary to identify new approaches to bring settlements in according with our expectations. In fact, by these methods, want it to replace landfills and incinerators with the alternative "friendly" environment. In Romania, the sorting of waste is an issue that must be addressed with strategies that to distinguish various types of materials. From the point of view of investments in waste recycling, they are granted or sponsored by using the profit and non-profit organizations. A product used after a certain time may be eliminated or recycled thereby contributing to the achievement of environmental objectives. The private companies or state by adopting green solutions can increase their profits, also, could design systems to reuse biodegradable waste without harming the natural ecosystem. Further, we present the principles that can be applied concerning recycling and disposal, namely

Waste Recycling efficient and economical

Therefore it is proposed and is being discussed "The concept of Zero Waste" with a focus on reuse of used products. Manufacture of another product to represent a means of reusing waste for to exit on the market.„ (Executive Committee, World Business Council for Sustainable Development). Waste recycling is a essential point in the development and sustainability of a community, but it can become unproductive if the costs of energy, materials and others exceed the production values of products made from new materials.

Minimizing and eliminating the volume and quantity of waste from landfills

In this way, are proposed alternative solutions for compacting waste because landfills are not a sustainable solution. For example, some products may be reused for a different purpose, namely waste tires can be used as a protective barrier seaports, tracks, etc. • Creating suitable channels collection and transport to locations where waste can be reused In the production process of materials are necessary several manufacturing steps, and some materials collected may be beneficial in the production of other goods. In this way, instead of depositing the waste we may transform into usable products. "Methods hierarchy of the waste disposal, classifies the environmental impact into six levels, namely (i) reduction, (ii) reuse, (iii) recycling, (iv) compost, (v) incineration (vi) landfill ". The names of "3R" comes from three main strategies for waste minimization reuse, recycling and reduction. "The systems for waste management depend on the success of interaction and integration a diversified range of activities, processes, equipment and stakeholders. Most times, when changes are introduced, they are added to an "existing waste management system in an outdated approach". When there is cooperation between stakeholders appears successful waste management plan. Promoting waste recycling and cooperation between the different stakeholders constitute a project management with the a high degree of risk because it is a challenge to achieve the intended purpose. According to specialists . "it is no theoretical perspective for environmental management application within organizations, and many researchers have applied legitimacy theory for explaining the practices of social and environmental reporting".

Principles and strategies for project management in organic waste recycling

In principle, an efficient waste management begins with preventing or minimizing waste generation, but if quantities of waste are produced when identifying solutions to managing the situation and intervenes through treatment. Besides the existence of present policies, approaches are needed ecological awareness must be promoted for carefully the use of natural resources. Therefore, in Europe it is desired to change current patterns through innovative alternatives that reduce energy consumption. In essence, it is important for organizations to focus on developing strategies using flexible and practical methods. In urban areas, try it an awareness on recycling of waste and household waste as fertilizer use in their own households because "organic waste can be beneficial nutrients for animal / plant, soil and fuel". Therefore, by implementing management projects may be introduced local and national markets. Also, waste must be sorted according to their time necessary for degradation or state in which we want them to reach for the manufacture of other products. However, must take into account that is necessary an government intervention and financial regulators. A phenomenon more common in developing countries is represented "informal recycling programs because of the low level of economic development. Low wages and low prices for goods and services creates viable profit margins from the collection and sale of secondary raw materials." .Unfortunately, the Landfill Directive in Romania does not provide, clearly, treatment methods for each type of waste. Thus, is at the discretion of each country to choose the best method for managing organic waste. Therefore, clear standards are needed to specify that organic waste can be reused in special areas, like compost. But in Romania grade organic waste is identified in the specific materials that are collected and recycled according to Framework Directive. This directive not assume that organic waste separation and composting are forms of recycling.

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Block 3

Waste Management Logistics and Technical Processes and Methods

Swachhta Action Plan

सत्यमेव जयते

Mahatma Gandhi National Council of Rural Education

Department of Higher Education

Ministry of Human Resource Development, Government of India

Hyderabad - 500004

Where there is Rural Wellbeing there is Universal Prosperity

Contents

Waste Management Logistics and Technical Processes and Methods – An Introduction

Logistics management in itself is a part of supply chain management. It includes planning, implementing, and controlling the efficient, effective forward (and reverse flow) and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customer's requirements. It is a field with immense possibility.

Waste Management Logistics considers waste a commodity that demands the same attention and efficiency as supply chain logistics. As we will learn in the subsequent course, the cost of mismanaging our waste or ignoring it can be multifold and the damage irreversible. However, if managed well, one's waste can well be another's wealth. The first chapter analyses the people involved in the waste chain, both formally and informally. The steps in waste management as well as the role of individuals and communities in waste generation and their responsibilities are explored. The processes of collection, recycling, composting, storage and transportation and extracting the best out of waste are the focus of chapter 2 and 3. Waste needs to be cut down at the consumer level as also at the producer level, as discussed in chapter 4. Trades of waste are discussed in chapter 4. Various case studies are discussed in chapter 5.

Garbage clearance regularly and conscientiously is a huge responsibility. Without proper understanding, support and cooperation of all individuals, it cannot be performed efficiently. While the course lays emphasis on collection, proper segregation, regular and systematic transportation, sorting, recovery of recyclables and final disposal in landfills, it also speaks of the need to reduce the quantum of waste generated so that the problem can be contained and be manageable. The end of each chapter contains a guideline for the teachers to impart the knowledge to students through a blend of classroom teaching, Activities, film viewing and discussions.

Chapter 1- Components of Logistics

Introduction

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. In waste management, logistics plays crucial role.

Objectives

- To understand steps in waste management logistics
- To understand Human and technological components in logistics
- To understand GPS and GIS in waste management

Structure

1.1 Introduction to Waste Management Logistics

1.2 Human Components, Technological Components

1.3 General Principles of collection and transportation

1.4 Social Aspects and Managerial Goals

1.5 Basics of GPS and GIS

1.1 Introduction to Waste Management Logistics

Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfilment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers" (Fig. 1.1).

The main logistics' task is to looping after the production process, Basic operations such as transfers and preparation to start the production process. All these activities have a significant share in the next phases – like offering the products to the clients.

For many years, the above definition has been treated as the best term and the most appropriate to describe the logistics. But, over the years, have been many changes on the market economy, which caused that the traditional meaning of the logistics has been proved to be insufficient. Today, enterprises are forced to activities, which are far away from the area described by the traditional definition. All these activities are connected with products management, which have been already used by the customers, and, meantime, the logistics process, directed from the source to the customer, has been reversed, and is directed from the customer to the source. It caused that new logistics concept has been developed, called reverse logistics (Municipal solid waste management manual, Govt. of India, 2014).

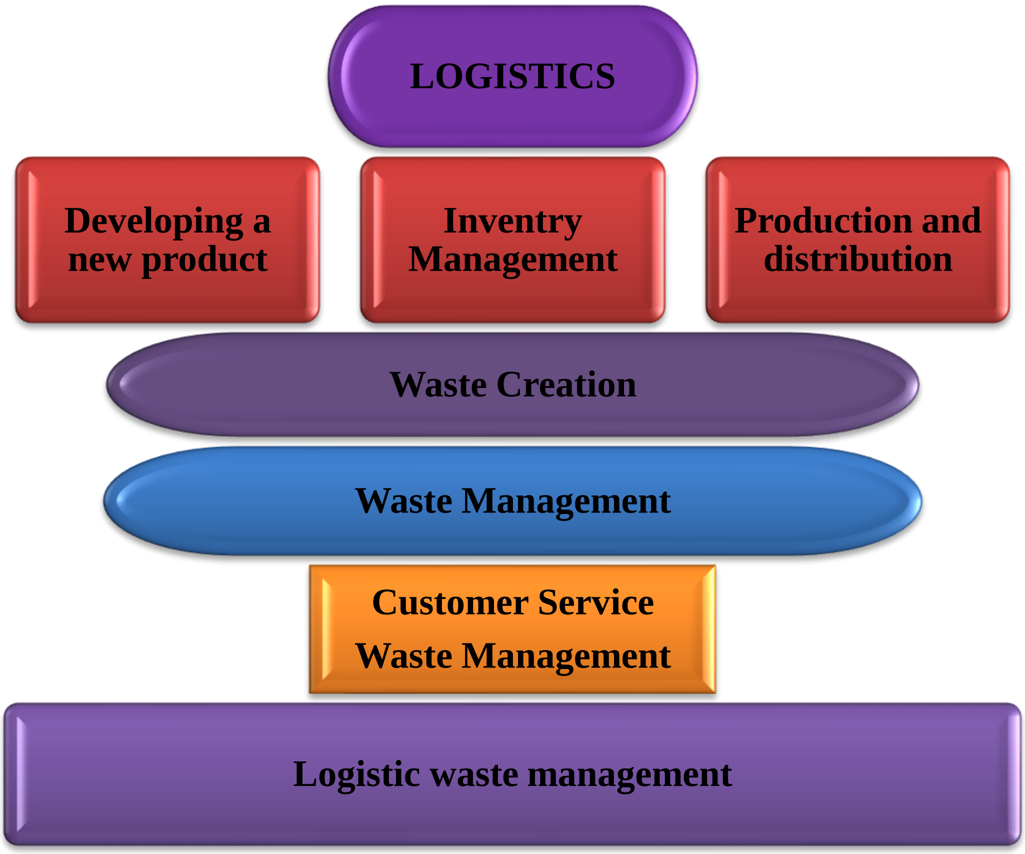


Fig 1.1 Logistics and waste management (Source: Waste to resources handbook, 2014)

Type and Quantity of Waste

The type and quantity of waste generated in emergency situations varies greatly. The main factors affecting these are:

- The geographical region (developed or less-developed country or region);
- Socio-cultural practices and material levels among affected population;
- Seasonal variations (affecting types of food available);
- The stage of emergency (volume and composition of waste may change over time); and
- The packaging of food rations.

In general, the volume of waste generated is likely to be small and largely degradable where the population is of rural origin and the food rations supplied are unpackaged dry foodstuffs. Displaced urban populations are more likely to generate larger volumes of non-degradable waste, especially where packaged food rations are provided.

Guideline values suggest that each person is likely to produce 0.5-1.0 litres of refuse per day with an organic content of 25 to 35 per cent and moisture content between 10 and 60 per cent (Adams, 1999). However, this is likely to vary greatly and estimates should be made locally (Municipal solid waste management manual, Govt. of India, 2014).

Different Categories of Solid Waste include

Organic waste: Waste from preparation of food, market places, etc.

Combustibles: Paper, wood, dried leaves, packaging for relief items, etc. (high organic and low moisture content)

Non-combustibles: Metal, tin cans, bottles, stones, etc.

Ashes/dust: Residue from fires used for cooking

Bulky waste: Tree branches, tyres, etc.

Dead animals: Carcasses of domestic animals and livestock Hazardous waste: Oil, battery acid, medical waste Construction waste: Roofing, rubble, broken concrete, etc (Municipal solid waste management manual, Govt. of India, 2014).

Initial Steps in Solid Waste Management

In order to establish effective solid waste management in the affected area the following process should be used (Fig.1.2).

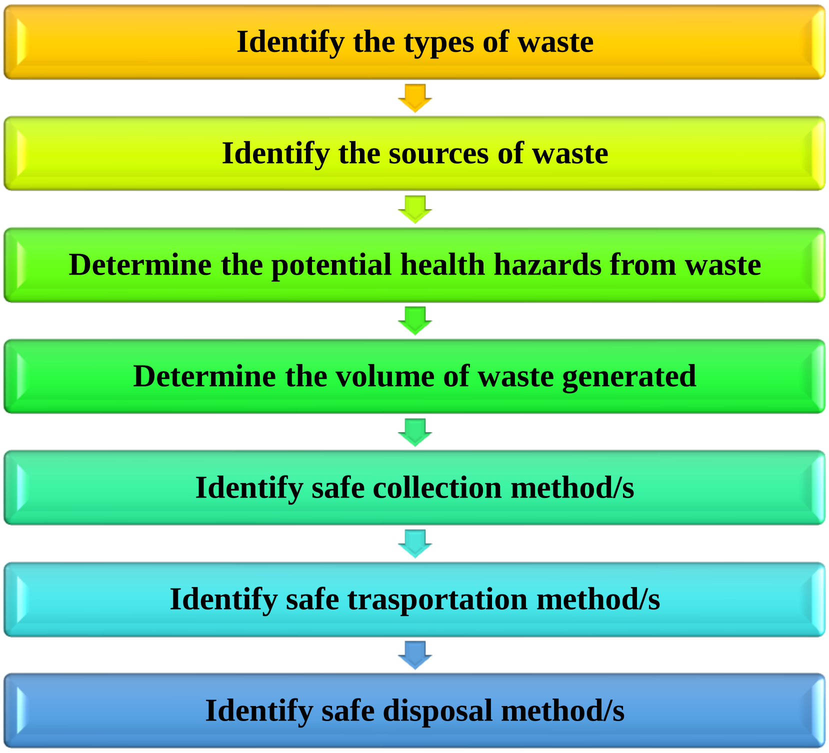


Fig. 1.2 Initial steps in solid waste management (Source: Waste to resources handbook, 2014)

Key Components of Solid Waste Management

Solid waste management can be divided into five key components

- Generation
- Storage
- Collection
- Transportation
- Disposal

Generation

Generation of solid waste is the stage at which materials become valueless to the owner and since they have no use for them and require them no longer, they wish to get rid of them. Items which may be valueless to one individual may not necessarily be valueless to another. For example, waste items such as tins and cans may be highly sought after by young children (Waste to resources handbook, 2014).

Storage

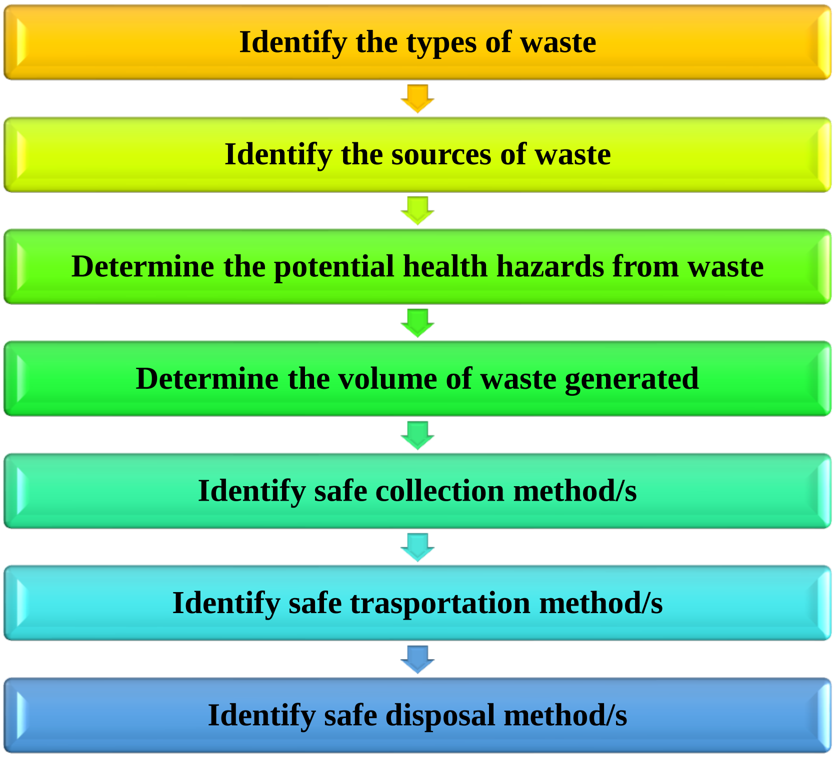


Fig. 1.2 Initial steps in solid waste management (Source: Waste to resources handbook, 2014)

Storage is a system for keeping materials after they have been discarded and prior to collection and final disposal. Where on-site disposal systems are implemented, such as where people discard items directly into family pits, storage may not be necessary. In emergency situations, especially in the early stages, it is likely that the affected population will discard domestic waste in poorly defined heaps close to dwelling areas. If this is the case, improved disposal or storage facilities should be provided fairly quickly and these should be located where people are able to use them easily. Improved storage facilities include:

- Small containers: household containers, plastic bins, etc.
- Large containers: communal bins, oil drums, etc.
- Shallow pits
- Communal depots: walled or fenced-in areas

In determining the size, quantity and distribution of storage facilities the number of users, type of waste and maximum walking distance must be considered. The frequency of emptying must also be determined, and it should be ensured that all facilities are reasonably safe from theft or vandalism.

Collection

Collection simply refers to how waste is collected for transportation to the final disposal site. Any collection system should be carefully planned to ensure that storage facilities do not become overloaded. Collection intervals and volumes of collected waste must be estimated carefully (Municipal solid waste management manual, Govt. of India, 2014).

Transportation

This is the stage when solid waste is transported to the final disposal. There are various modes of transport which may be adopted and the chosen method depends upon local availability and the volume of waste to be transported. Types of transportation can be divided into three categories:

- Human-powered: open hand-cart, hand-cart with bins, wheelbarrow, tricycle
- Animal-powered: donkey-drawn cart
- Motorised: tractor and trailer, standard truck, tipper-truck

Disposal

The final stage of solid waste management is safe disposal where associated risks are minimised. There are four main methods for the disposal of solid waste:

- Land application: burial or landfilling
- Composting
- Burning or incineration
- Recycling (resource recovery)

The most common of these is undoubtedly land application, although all four are commonly applied in emergency situations (Municipal solid waste management manual, Govt. of India, 2014).

1.2 Human and Technological Components in Waste management

The informal sector, constituting kabadi system and waste pickers/rag pickers, plays an important role in the SWM value chain by recovering valuable material from waste. They help reduce environmental impacts by improving resource recovery and reducing disposal requirements (Fig. 1.3). The integration of the informal sector into the formal solid waste management system will contribute to the reduction of the overall system costs, provide support to the local recycling industry and create new job opportunities (Waste to resources handbook, 2014).

India has a long history on waste collectors. Their poor living conditions, harsh behaviour towards them, segregation from society, by being considered ‘unclean’ due to their profession has led to their being a marginalized society even after seven decades of India’s Independence.

(Watch Film: Waste Picker’s life and livelihood. 11 min.

https://www.youtube.com/watch?v=aLda8O2ySMc)

This short film portrays the haplessness as well as government and public apathy towards waste pickers, even though their contribution to modern society is immeasurable. However, with time, this bias is changing. Today waste pickers have been turned into ‘collectives’ or ‘micro and small enterprises’ (MSE-comprising of fewer than 50 employees). They are the backbone of a good cost-recovery system out of waste collection. The garbage collected itself is the hidden wealth with potential to pay back. A fee collected from every household or business for collection and disposal is an important component (Waste to resources handbook, 2014).

Transportation options

Where bins or collection containers require emptying, transportation to the final disposal point is required. As described, waste transportation methods may be human-powered, animal-powered or motorised.

Human-powered

Wheelbarrows are ideal for the transportation of waste around small sites such as markets but are rarely appropriate where waste must be transported considerable distances off-site. Handcarts provide a better solution for longer distances since these can carry significantly more waste and can be pushed by more than one person. Carts may be open or can be fitted with several containers or bins.

Animal-powered

Animal-powered transportation means such as a horse or donkey with cart are likely to be appropriate where they are commonly used locally. This may be ideal for transportation to middle distance sites (Municipal solid waste management manual, Govt. of India, 2014).

Motorised

Where the distance to the final disposal site is great, or where the volume of waste to be transported is high, the use of a motorised vehicle may be the only appropriate option. Options include tractor and trailer, a standard truck, or a tipper-truck, the final choice depending largely on availability and speed of procurement (Municipal solid waste management manual, Govt. of India, 2014).

Fig. 1.3 Refuse collection vehiclesandcontainers (Waste to resources handbook, 2014).

On-site Disposal Options

The technology choices outlined below are general guidelines for disposal and storage of waste on-site, these may be adapted for the particular site and situation in question (Waste to resources handbook, 2014).

Communal Pit Disposal

Perhaps the simplest solid waste management system is where consumers dispose of waste directly into a communal pit. The size of this pit will depend on the number of people it serves. The long-term recommended objective is six cubic metres per fifty people. The pit should be fenced off to prevent small children falling in and should generally not be more than 100m from the dwellings to be served. Ideally, waste should be covered at least weekly with a thin layer of soil to minimise flies and other pests (Waste to resources handbook, 2014).

1.3 General Principles of Collection and Transportation

Collection of segregated municipal waste is an essential step in solid waste management. Inefficient waste collection service has an impact on public health and aesthetics of towns and cities. Collection of wet and dry waste separately enhances the potential of cost effective treatment of such wastes cost effectively and ensure optimum advantage from the recyclable material fed into the system (Municipal solid waste management manual, Govt. of India, 2014).

Waste collection services are divided into primary and secondary collection

- Primary collection refers to the process of collecting waste from households, markets, institutions and other commercial establishments and taking the waste to a storage depot/ transfer station or directly to the disposal site, depending on the size of the city and the waste management system prevalent in the city.

- Secondary collection includes picking up waste from community bins, waste storage depots or transfer stations and transporting it to waste processing sites or to the final disposal site.

Primary collection must ensure separate collection of certain waste streams / fractions depending on the separation and reuse system applied by the respective town/ city. Segregated waste must be stored on-site in separate containers for further collection and should be kept separate during all steps of waste collection, transportation and processing (Waste to resources handbook, 2014).

A well synchronised primary and secondary transportation system, with regular and (with respect to primary collection) well communicated intervals of operation is essential to avoid containers' overflow and waste littering on streets. Further, the transport vehicles should be compatible with the equipment design at the waste storage depot and should be able to transport segregated waste. They should also be easy to maintain.

The informal "kabadi system" network forms an important link in the overall waste recycling system prevalent in the country. They can be compared to micro-entrepreneurs who buy reusable and recyclable material like newspapers, metal, glass, cardboards, plastics, etc. from households or commercial areas. Citizens should be encouraged to continue the practice of selling recyclable wastes to the "kabadi system", as they constitute the first link in the waste recycling system (Waste to resources handbook, 2014).

Primary collection of segregated municipal solid waste from individual households and establishments (door to door collection) is accomplished through the use of containerized push carts/tri-cycles, small mechanized vehicles, compactors and/or tipping vehicles depending on the terrain of the locality, width of streets and building density.

Spacious and well- lit safe neighborhoods allow collection systems with compactor vehicles and tipping equipment which are more efficient. Narrow streets do not allow for the use of conventional primary collection vehicles. In cramped neighborhoods, hand carts/push carts, tri-cycles and/or small mechanized vehicles may be used for door to door collection of waste, which may then be transferred to a larger vehicle in the vicinity. Where access to individual houses/establishments is difficult, hand carts/ rickshaws could be made to stand at designated spots.

In hilly areas many of the houses are accessible only by means of footpaths or through steps, thus restricting the use of hand carts and/or tri-cycles. In such instances, waste collectors should ideally carry a waste bag/basket on their back for wet waste and through another bag collect segregated dry waste from each household(Waste to resources handbook, 2014).

Waste collection route planning is critical to ensure an efficient door to door collection and transportation system. In hilly areas, waste collection should ideally start at the highest point and proceed to lower levels. This would ensure that waste collectors/waste collection vehicles need not carry increasing amounts of waste up steep slopes (Waste to resources handbook, 2014)..

The frequency of door to door collection should be determined by the density of population, the collection system and climatic conditions. In hot and humid regions, at least wet waste is to be collected on a daily basis. Isolated houses, shops and establishments may be served on a less than daily basis, depending on quantities of waste generated. Motorized collection vehicles are able to handle relatively larger quantities of waste and are preferred for periodic waste collection (Waste to resources handbook, 2014).

Domestic waste could be collected in the morning hours before 12 noon. Waste from the commercial areas could be collected between 10.00 am and 2 pm. Vegetable market waste should be collected in non-peak hours either early morning or late in the afternoon or at night. The collection of market waste might also need to be done more than once a day.

The municipal authority may promote/engage RWAs, CBOs, NGOs/SHGs or the private sector to provide door to door collection services. Penal provisions may be introduced after assessment/review of overall management system, for failure of service where contracts are awarded. Frequency of collection is determined by the density of area, collection system and climatic conditions. E.g. wet waste should be collected daily in hot and humid areas

Vehicles and equipment for primary collection

Vehicles Typically Used for Primary Collection

- ✓ Hand carts/tricycles with containers or bins
- ✓ Tri-cycle with hydraulic tipping containers
- ✓ Mini-truck with hydraulic tipping container

✓ Four Wheeled mini-trucks with garbage collection bins

Hand Carts/Tricycle with Containers or Bins

Hand carts should have a capacity to carry 4 to 6 containers of 25 to 40 liter capacity (Fig. 1.4)

The containers should be of two colours, green (wet waste) and blue (dry waste), for collection of wet and dry waste separately (refer to figure 1.4). Bins should be made of HDPE, injection molded, UV tested, universally used as standard garbage handling bins (Waste to resources handbook, 2014).

Containerized hand carts are suitable for door to door collection of municipal solid waste from households, shops and establishments from narrow lanes and hilly areas and also for collection of street sweepings where women sanitation worker are involved in street sweeping. Bins/ containers can be easily unloaded into secondary collection bins or secondary transport vehicles, based on the prevalent collection and transportation system in the ULB without depositing the waste on the ground necessitating multiple handling of waste (Waste to resources handbook, 2014).

Tricycles with 6 to 8 containers from 40 liters to 60 liters capacity can also be used for door to door collection of waste from narrow lanes where male work force is engaged to facilitate picking up larger quantity of waste in one trip and taking the waste to a secondary waste storage depots placed at longer distance (Waste to resources handbook, 2014).

Fig 1.4 Hand carts (Source: Waste to resources handbook, 2014)

Tricycle with Hydraulic Tipping Containers (Fig. 1.5)

MSW tricycles should have mild steel epoxy painted, tipping containers of 350 liters (140 Kilograms/ trip), mounted on a standard tricycle. This is suitable for door to door collection from small lanes and small generators.

Fig. 1.5 Tricycles (Source: Waste to resources handbook, 2014)

Light Commercial Vehicles (Mini Trucks) With Hydraulic Tipping Containers (Fig. 1.6): This vehicle is suitable for door to door collection of segregated waste from lanes of width less than 5 meters with a total pay load capacity of nearly 600 – 900 kilograms per trip.

The load height is approximately 1500 mm from the ground level. It should have a leak proof MS load body with drainage tube and plug. The small tipper should be built on a suitable chassis. These vehicles should have four openings, 2 on each side to facilitate direct transfer of waste from a domestic bin to the vehicle. It can also have a central removable partition to facilitate storage of segregated components of waste. It is desirable to use upto 3 m^3 capacity vehicles for door to door collection to cater to a large number of houses in a single trip (Municipal solid waste management manual, Govt. of India, 2014).

Four Wheeled Mini Truck With International Standard Garbage Collection Bins: The main advantage of using bins instead of a hydraulic container is that the load height can be brought down from 1500 mm in case of the previous design to 1200 mm from ground or less, if the bins are brought down for collection.

Avoidance of hydraulic tipping will make it suitable for use in remote places also, where suitable provisions for maintenance of hydraulic component of large number of vehicles may not be available and is also costly and time consuming (Waste to resources handbook, 2014).

A typical set up: The vehicle can carry 8 bins of minimum 240 liters. Bins should be made of injection molded HDPE. Each mini truck should carry 4 green containers for wet waste and 4 blue containers for dry waste.

Fig. 1.6 Mini Truck with hydraulic container (Municipal solid waste management manual, Govt. of India, 2014)

Organizing the Unorganized - Towards formalization and social inclusion of informal waste pickers and recyclers

Location: Pune, Pimpri Chinchwad, Maharashtra

Main Players: Kagad Kach Patra Kashtakari Panchayat (waste pickers trade union), SWACH (co-operative), Pune and Pimpri Chinchwad Municipal Corporations

Table 1.1 Estimates for Deployment of Vehicles and Manpower for Primary Collection

Vehicle for primary collection	Number of Households to be covered in different areas	Population Served	Staff Required
Push Carts	Congested area: 300 Households Medium Density area: 200 Household Scattered Area: 125 House holds Hill area : 85-90 Households	1500 1000 625 400 to 450	1 person per push cart
Tricycle	Congested area: 300 households Medium Density area: 250 households Scattered Area: 200 House holds Hill area : 125Households	2000 1500 1000 Hilly areas are difficult to serve and population/ households served should be decided based on operational conditions	1 person per tri-cycle
Light Commercial Vehicles (LCV) having 500 to 700 kg capacity	1000 households	5000	1 driver & two labour per LCV
LCV with more than 700 kg capacity	1500 to 2000 households	7500 to 10,000	1 driver & two labour per LCV

Table1.2 Elements of primary waste collection system

Source	Primary Collection services	Transportation	PPe for waste handler
Societies/ Apartment Complexes	Door to Door collection services Minimum of Two bins for collection of wet waste and dry waste (10-15L)	Containerized light weight handcarts Tricycles for both men/ women Pick up Vans Motorized waste collection vehicle Any suitable combination of the above	Gloves Shoes Clothes that cover whole body
	A pair of community bins of		
	60 litres(20 to 30 kg) or		
	120 litre capacity (40 to 60 kg) or		
	240 lit capacity (80 to 120 kg) or		
	1.1 cu. m capacity (300 to 450kg) depending on no of houses to be served (i.e. 12, 24, 48, 200 units). The specifications should be as per Central Institute of Plastics Engineering and Technology (CIPET) advise		
	Contract for door to door collection should be given to Private sector/ RWAs/ CbOs/ NGOs/SHGs		
Inaccessible Residential Areas	Two separate community bins/ containerof 60 to 120 litre capacity for 20 to 40 dwelling units Two domestic bins for storage of waste at source 5, 10, 15, 20 litres (for 2 to 8 Kg waste) capacity, as per CIPET specification	Containerized light wieght hand carts Tricycle for both men/ women Waste collected from the area should be transferred to a LCV outside the slum area	Gloves Shoes Clothes that coverwhole body

Table 1.2: Elements of Primary waste collection System

Source	Primary Collection services	Transportation	PPe for waste handler
Residential areas	Door to door collection services for segregated waste 12 to 15 litres capacity domestic bins, one of them with lid, made as per CIPET specification Contract for door to door collection should be given to Private firm/NGOs/ RWA/ SHGs Large commercial complexes could use 3.0 cu.m.to 7.0 cu.m. container	Containerized Handcarts Tricycles for both men and women Pick up Vans Motorized waste collection vehicle	Gloves Shoes Clothes that coverwhole body
Hilly areas	Door to door collection service for segregated waste Manual collection or small motorized vehicles work well Door to door collection service for segregated waste 5, 10, 15, 20 litres (for 2 to 8 Kg waste) capacity, HDPE, injection moulded, tested bins Two domestic bins of 12 to 15 litres or a pair of community bins of 60, 120, 240 litre depending on the number of houses to be served (20, 40, 80 houses)	Lightweight containerized handcarts Tricycles for both men and women Pick up Vans Motorized waste collection vehicle Combination of vehicles specified above	Heavyduty gloves Shoes Clothes that coverwhole body Face mask

Technological Component: Waste Handling Equipment

To make the process of waste collection, transportation, processing and further action, every waste management service provider must be equipped with efficient waste management tools (Waste to resources handbook, 2014).

1. Equipment for Collection- Bags and Bins

    a. Biodegradable Garbage Bags: Garbage liners and garbage bags are easy to use solutions to contain and transport waste. They are widely used across the globe. Linear Low Density(LLD) trash bags are strong, flexible and highly resistant to puncturing and tearing. They are ideal for kitchen trash, construction debris or trash that includes glass, metal, wood, cardboard or irregular shaped items. High Density (HD) can liners are a more cost-effective option. Manufactured from different resins, they are thinner than Linear Low Density bags and are not as puncture resistant, yet they can carry quite heavy loads. However, there are certain things to remember:

- Garbage bags need exposure to sunshine, water and microbes to degrade.
- These bags are grade 7 plastic and cannot be recycled with plastics of grades 1 and 2. Their presence can spoil the entire recycling process.
- A better alternative to biodegradable garbage bags is compostable garbage bags. These break down in about 6 months (vis-a-vis a regular plastic bag that takes over 100years)

Note: ‘Biodegradable’ refers to any material that breaks down and decomposes in the environment while ‘compostable’ refers to organic matter that breaks down to become nutrient-rich soil (Waste to resources handbook, 2014).

b. Household Bins: These must be lidded, with or without foot pedal/wheels. These bins are usually made of durable and leak proof material such as plastics. It is important to wash and dry the household bins every day after the waste is collected by the waste collectors (Waste to resources handbook, 2014).

c. Community Bins with Lids: Community bins must have lids to prevent entry of flies, rodents or stray animals. Special bins which can be lifted and tipped into the collection vehicle should be provided for convenience of service.

Fig. 1.7 Community Bins with Lids

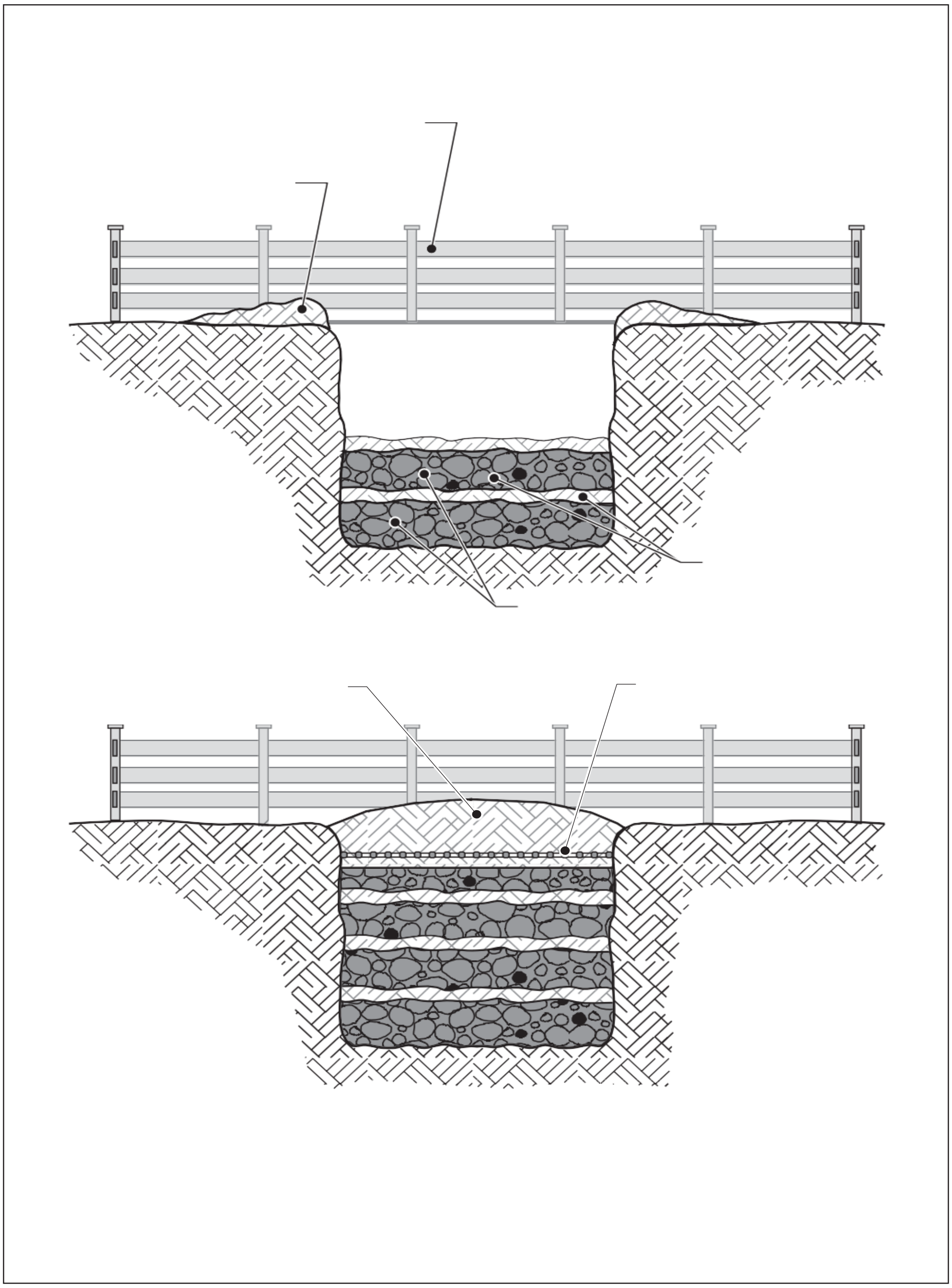


Fig. 1.8 Communal solid waste pit (Source: Municipal solid waste management manual, Govt. of India, 2014)

Family Pit Disposal

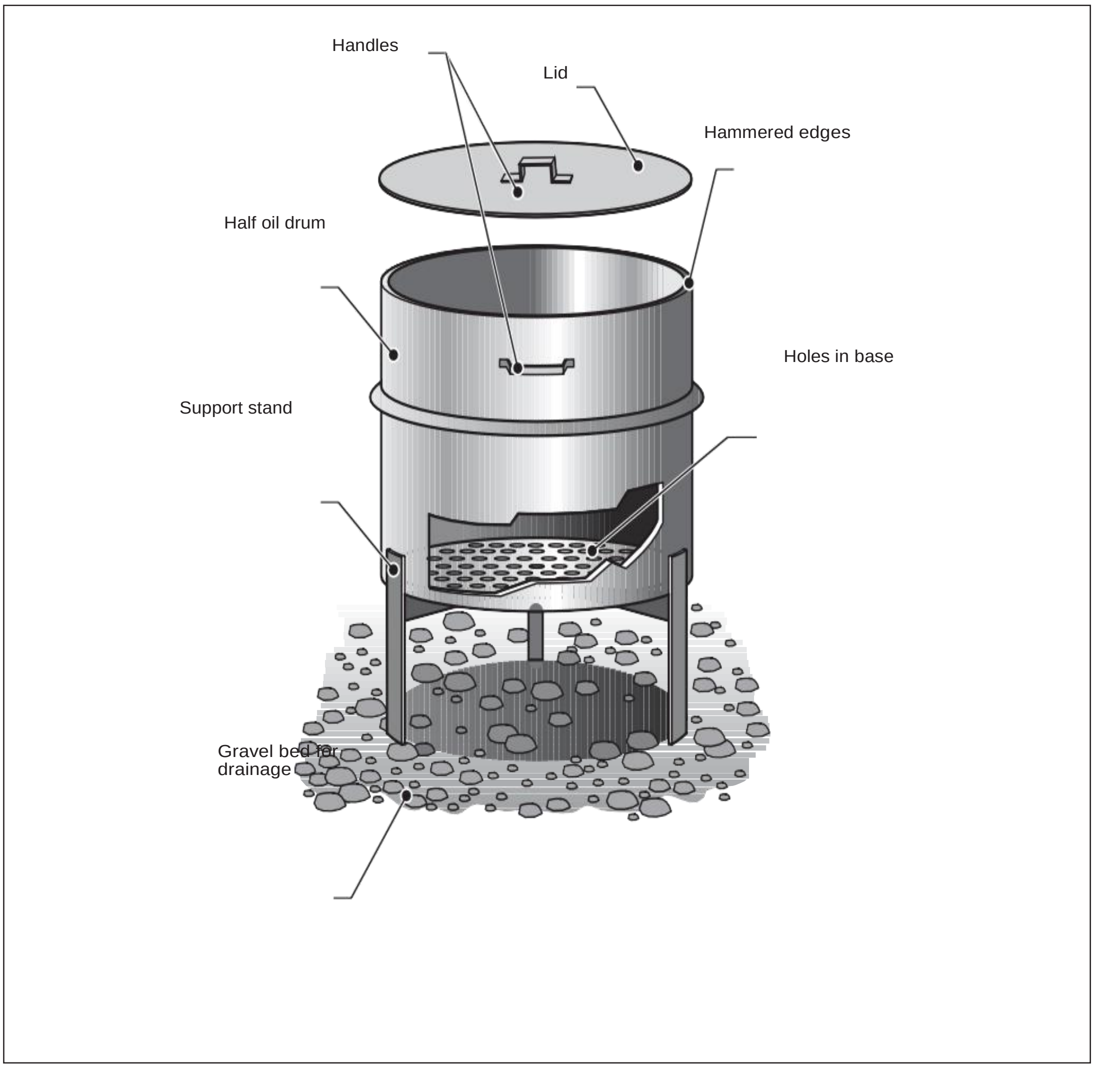
Family pits may provide a better long-term option where there is adequate space. These should be fairly shallow (up to 1m deep) and families should be encouraged to regularly cover waste with soil from sweeping or ash from fires used for cooking. This method is best suited where families have large plots and where organic food wastes are the main component of domestic refuse.

Advantages:Families are responsible for managing their own waste; no external waste workers are required; and community mobilisation can be incorporated into hygiene promotion programme.

Constraints: Involves considerable community mobilisation for construction, operation and maintenance of pits; and considerable space is needed (Waste to resources handbook, 2014).

Communal Bins (Fig.1.9)

Communal bins or containers are designed to collect waste where it will not be dispersed by wind or animals, and where it can easily be removed for transportation and disposal. Plastic containers are generally inappropriate since these may be blown over by the wind, can easily be removed and may be desirable for alternative uses. A popular solution is to provide oil drums cut in half (Figure 1.3). The bases of these should be perforated to allow liquid to pass out and to prevent their use for other purposes. A lid and handles can be provided if necessary (Waste to resources handbook, 2014).



Advantages: It is rapid to implement; and requires little operation and maintenance.

Constraints: The distance to communal pit may cause indiscriminate disposal; and waste workers required to manage pits. In general, a single 100-litre bin should be provided for every fifty people in domestic areas, every one hundred people at feeding centres and every ten market stalls. In general, bins should be emptied daily.

Advantages: Bins are potentially a highly hygienic and sanitary management method; and final disposal of waste well away from dwelling areas (Waste to resources handbook, 2014).

Constraints: Significant collection, transportation and human resources are required; sys- tem takes time to implement; and efficient management is essential.

Family Bins

Family bins are rarely used in emergency situations since they require an intensive collection and transportation system and the number of containers or bins required is likely to be huge. In the later stages of an emergency, however, community members can be encouraged to make their own refuse baskets or pots and to take responsibility to empty these at communal pits or depots.

Advantages:Families are responsible for maintaining collection containers; and potentially a highly sanitary management method (Waste to resources handbook, 2014).

Constraints:In general, the number of bins required is too large; significant collection, transportation and human resources are required; takes time to implement; and efficient management essential.

Communal Disposal without Bins

For some public institutions, such as markets or distribution centres, solid waste management systems without bins can be implemented, whereby users dispose of waste directly onto the ground. This can only work if cleaners are employed to regularly sweep around market stalls, gather waste together and transport it to a designated off-site disposal site. This is likely to be appropriate for vegetable waste but slaughterhouse waste should be disposed of in liquid-tight containers and buried separately.

Advantages:System rapid to implement; there is minimal reliance on actions of users; and it may be in line with traditional/usual practice.

Constraints:Requires efficient and effective management; and full-time waste workers must be employed.

2. **Transport Equipment**

For Primary level transportation (Fig. 1.10)

a. Wheel barrow: It has a single wheel. It is good only for carrying waste to the community collection centres. It is unsuitable for narrow streets, but suitable if the roads are paved well.

b. Hand cart: A three-wheeled cart is more stable especially on poor roads. It can carry larger volumes

1 m^3. It is suitable for door to door collection in crowded areas and for transporting till the community bin or local transfer centres.

c. Cycle cart: It can have separate compartments one for wet and another for dry waste. It also has drop-down sides to make loading / unloading easy. It is not suitable for bad roads or steep slopes. It can carry up to 3 m^3. In some areas animals like camel/donkey drawn carts are used. They can carry on steep gradients with ease hence do not need very good roads.

d. Tractor with a trailer: This is costlier. It can carry 4 m^3 to a distance of about 20 km.

Fig. 1.10 Equipment for Waste Collection and Transportation (Municipal solid waste management manual, Govt. of India, 2014)

Vehicles typically used for secondary transportation of wastes

- Dumper placers/skip loaders,
- Refuse collector without compactor,
- Refuse collection mobile compactors
- Mini truck with tipping floor
- Hook loader/hook lifter

For Secondary level transportation

a. **Truck with bin lifter:** These are suitable for transferring or collecting community bins.

Fig. 1.11 Skip Truck (Dumper Placer) (Municipal solid waste management manual, Govt of India, 2014)

b. **Tipping Lorries:** A waste collecting tipper box is used for emptying curb-side bins. It needs good roads.

c. **Flatbed crane truck:** These are useful for transfer stations, markets and industrial areas. It has its own crane for loading and unloading.

d. **Hydraulic compactors**: This is good for low-density waste in large quantities where roads are good. They are not suitable for high density residential waste. This is expensive and involves high-maintenance cost. Other machines used for handling MSW include auto hopper (a tipping bin is fixed behind an auto rickshaw), high-rise auto, truck mounted street sweeper, mobile toilet, muljet (mini jetting three and four wheelers), super sucker (to empty septic tanks). Trucks are often equipped with GPS tracking devices (Waste to resources handbook, 2014).

Fig. 1.12 Medium size compactor truck (Source: Waste to resources handbook, 2014)

3. Transfer Stations : Transfer stations allow waste to be deposited close to where it is produced and then be taken to disposal sites farther away. This makes the collecting and transporting system more efficient and cost-effective. It also allows the waste to be screened to remove recyclable materials. In addition, transfer stations reduce illegal dumping.

a. Simple transfer station: Manual transfer

b. Mechanically loaded transfer station: Waste is tipped on the concrete floor, from where mechanical shovelling is done.

4. **Protective equipment:** The staff should be provided with boots, gloves, hard hats, dust masks, high visibility jackets and safety glasses to protect them from sharp items, pathogens, heavy metals and dust and other chemicals.

5. Street Sweeping Machines:

(Watch Film: Street Sweeping RAVO 5 Series Sweeper, Duration 4 min https://www.youtube.com/watch?v=3p1M1C2gYsg)

Street sweeping is an important part of keeping the city clean. It improves air quality and creates a good ambience. Traditionally, sweeping streets is done manually, with brooms on bamboo sticks. This is a tedious, time consuming daily routine (Waste to resources handbook, 2014).

Street sweeping machines are replacing human street sweepers in many urban areas. The machines are mounted on truck bodies and can vacuum debris accumulated on streets.

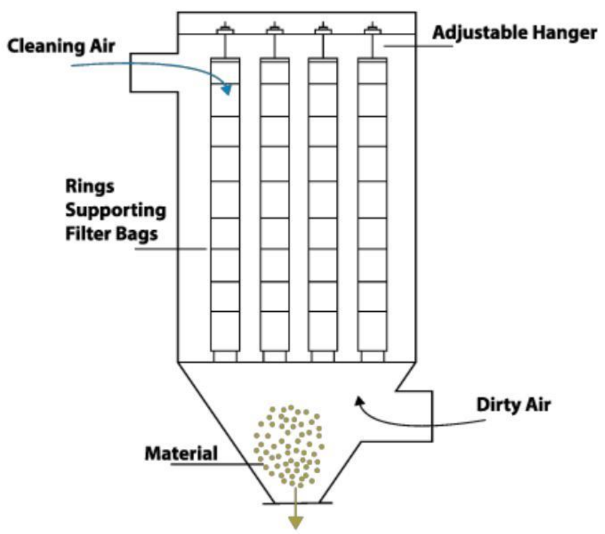
Humans sweeping the streets can only remove large particles, and some dust. Smaller particles usually run off along with rain and can cause water pollution. The US-EPA considers the mechanical street sweeping as the best practice in protecting water bodies. The street sweeper machine is capable of collecting particles up to 2.5 µ in size. Water tanker with sprayer loosens dust and debris, which is the vacuumed into the collection bin/ hopper. Regenerative air street sweepers remove debris by centrifugal force, but can be noisy and requiring an extra vacuum pump. These machines have become popular on large railway stations and national highways in India. However, they cannot replace human labour entirely, as many streets are not compatible for this machine (Waste to resources handbook, 2014).

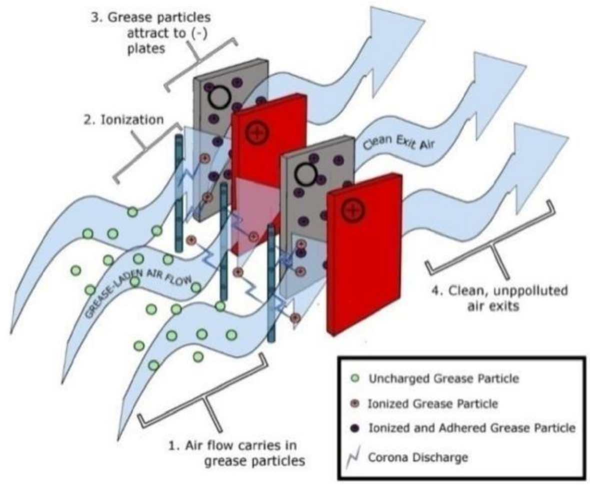
6. Baling Machines: After the segregation of waste into recyclable categories, they need to be baled and tied with wires for easy transport (Fig. 1.13).

Fig. 1.13 Baling Machine (Source: Waste to resources handbook, 2014)

7. Technology to Control Air Pollution: As emission control designs get stringent, incinerators need to meet air pollution emission standards for particulates, sulphur oxides (SO2 and SO3), non-methane hydrocarbons, (H), Nitrogen oxides (NOx) and

carbon monoxide levels in the flue gases. Fine particles from the gas stream are removed by passing through baghouses or electrostatic precipitators (Fig.1.14).





A. **Bag Filters**	**B. Electrostatic Precipitator**

Fig 1.14 Equipment to Control Air Pollution (Source: Waste to resources handbook, 2014)

a) Baghouses: Baghouses have been in existence for a long time and their usefulness is beingcontinually extended with advances in media? or substrate material. Baghouses may be reverse air, shakers or pulse jet. They contain a medium which acts as a substrate to which the fine particles adhere. In the process, a filter cake is produced, which needs to be removed physically. The filter media could be fibre glass or ceramic for high temperatures, or else cotton, polyesters or Teflon coatings, matched as per the gas stream's characteristics. These are usually rigid panels, fan-fold ganged together in parallel units (Waste to resources handbook, 2014).

b) Electrostatic precipitator (ESP):An ESP is a filtration device that removes fine particles, like dustand smoke, from a flowing gas using the force of an induced electrostatic charge minimally impeding the flow of gases through the unit.

Environmental Informatics for Waste Management

RFID technology, "radio-frequency identification", refers to a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves. RFID is one method for Automatic Identification and Data Capture (AIDC). RFID tags can be placed on waste bins, garbage trucks. The RFID transponders detect automatic reading, and also detect and signal irregularities in implementation of planned route and scheduling. In some places where bins are tagged, there is a feeling of outrage and intrusion of privacy among the people who fear that the information on the contents of the waste bin could be used to levy a fine for contamination of recycling bins or charge excess for the packaging waste in bins! There are mixed reactions. There are fears that by analysing the content of the trash, the Government bodies can identify personal information about the eating habits of your children or the volume of alcohol consumed. This could be linked to counselling by healthcare workers, etc. Nevertheless, there is great potential for using the information generated by RFID bins, along with RFID

tagging at item level to help manage communities, enforce our rules and improve the lives of those who need help to avoid petty crime and antisocial behaviour. Data collection, evaluation, assessment through GIS and GPS and associated special analysis methods are possible through environmental informatics of waste management (Waste to resources handbook, 2014).

Fig. 1.15 RFID Tagged Bin (Source: Waste to resources handbook, 2014)

Fig. 1.16 Diagrammatic Representation of How RFID Works and Cloud-Based Management of Solid Waste in Cities (Source: Sharmin and Al Amin, 2016)

1.4 Social Aspects and Managerial Goals:

People do realize that solid waste is an issue. They are aware of the detrimental effects of littering. Yet, their awareness does not prevent them from littering or dumping mixed garbage arbitrarily. This attitude-behavior gap is often due to a variety of reasons including convenience, social norms, lack of public participation, and lack of education and awareness of effective waste management techniques. Causes of public littering include:

- a lack of social pressure to prevent littering,
- absence of realistic penalties or consistent enforcement,
- lack of knowledge of the environmental effects of littering,
- the amount of litter already present at a particular site,
- presence of signs referring to litter,
- number and/or placement and appearance (if any) of waste collection bins at the site.

It is observed that people participate in recycling buybacks and non-littering initiatives not only because of government support or economic reasons, but also because of the social pressure created by the community. They believe that by not adapting to social pressure, they are likely to be looked down upon by their neighbors. Failure to recycle is considered anti-social.

Improving solid waste management requires efforts to raise public awareness, increase funding, build expertise, and invest in infrastructure. To make progress, communities need to embrace new systems for SWM that are participatory, contextually integrated, complex, and adaptive. A positive and proactive partnership approach to waste contractors goes a long way in a successful waste management programme.

Managerial Goals

Certain managerial goals should be set by the municipality. A clear understanding of real waste performance through an audit of waste collection, segregation, recycling, reuse, energy recovery and disposal is needed. The economic model should also be strong. The citizens should pay for the services of waste handling. The waste management operators should get fair income from the sale of compost, recyclables, etc. It is possible that there are areas in the neighbourhood where the residents are too poor to pay a fee for waste collection. In such cases the municipality should pay the operator, based on the total volume of waste delivered to the transfer station.

1.5 Basics of GIS and GPS

Solid waste management has been a leading concern for all the developing countries. It poses serious threats in terms of environmental damage, health hazards and economic cascade. There has to be apt planning for proper waste management by analyzing the area and its waste situation. Geographical Information System and other technologies like RFID, GPS etc. can be used as a decision support tool for proper planning of solid waste management (Wang, 1999).

The utilization of Geographic Information Systems (GIS) and Global Positioning Systems (GPS) to capture and analyze spatial data is well known; and is growing in municipal solid waste management (MSWM), e.g. Information on geographic locations of municipal solid waste collection/dump sites (MSWCS) can help decision-making in MSWM, including collection route planning, dumps cleanup, and future siting of collection sites in order to enhance quality of water resources. Many studies have mapped solid waste collection systems and refuse dumps and these studies to analyzed MSW collection efficiencies(Wang, 1999).

Global Positioning System (GPS) has tremendous potential for better transport management/planning. Traffic management, emergency services (fire service, accident relief, ambulance service, policing, etc.), are the few areas where GPS can play significant role due to its capability to provide near accurate location (latitude, longitude, altitude) and other details. Traffic routing, movement of vehicles, VIP movement, taxi service, fleet management for passenger and cargo services etc. becomes easier by using GPS receivers on vehicles. Use of GPS along with GIS database of the city can help to perform the above tasks more effectively. GPS is also very useful in creating accurate spatial databases. Global positioning system is an earth-orbiting Satellite based system that provides signals anywhere on or above earth, 24 hours a day, round the year, and irrespective of weather, and that can be used to determine precise time and the position of a GPS receiver in three dimensions. This technology is increasingly used as input for GIS particularly for precise positioning of geo-spatial data and for collection of data from the field. One major advantage is its capability of forming a powerful building block in an integrated system. GPS together with a co-ordinate system and GIS produces a map and the map facilitates navigation. GPS is rapidly becoming an important tool to the GIS and Remote sensing industries (Wang, 1999).

Concept of GPS

GPS consists of a constellation of radio navigation satellite and a ground control segment. It manages satellite operation and users with specialized receivers who use the satellite data to satisfy a broad range of positioning requirements (Wang, 1999).

In brief, following are the key features of GPS:-

1 The basis of GPS is „triangulation‟ more precisely trilateration from satellites

2 A GPS receiver measures distance using the travel time of radio signals.

3 To measure travel time GPS needs very accurate timing that is achieved with some techniques.

4 Along with distance, one needs to know exactly where the satellites are in space.

5 Finally one must correct for any delays, the signal experience as it travels through the atmosphere.

The whole idea behind GPS is to use satellites in space as reference points for location here on earth. By very accurately measuring the distances from at least three satellites, we can „triangulate‟ our position anywhere on the earth by resection method.

GPS Elements

GPS has 3 parts: the space segment, the user segment, and the control segment, Figure-1.17 illustrates the same. The space segment consists of a constellation of 24 satellites, each in its own orbit, which is 11,000 nautical miles above the Earth. The user segment consists of receivers, which can be held in hand or mount in the vehicle. The control segment consists of ground stations (six of them, located around the world) that make sure the satellites are working properly. More details on each of these elements can be referred from any standard book or online literature on GPS

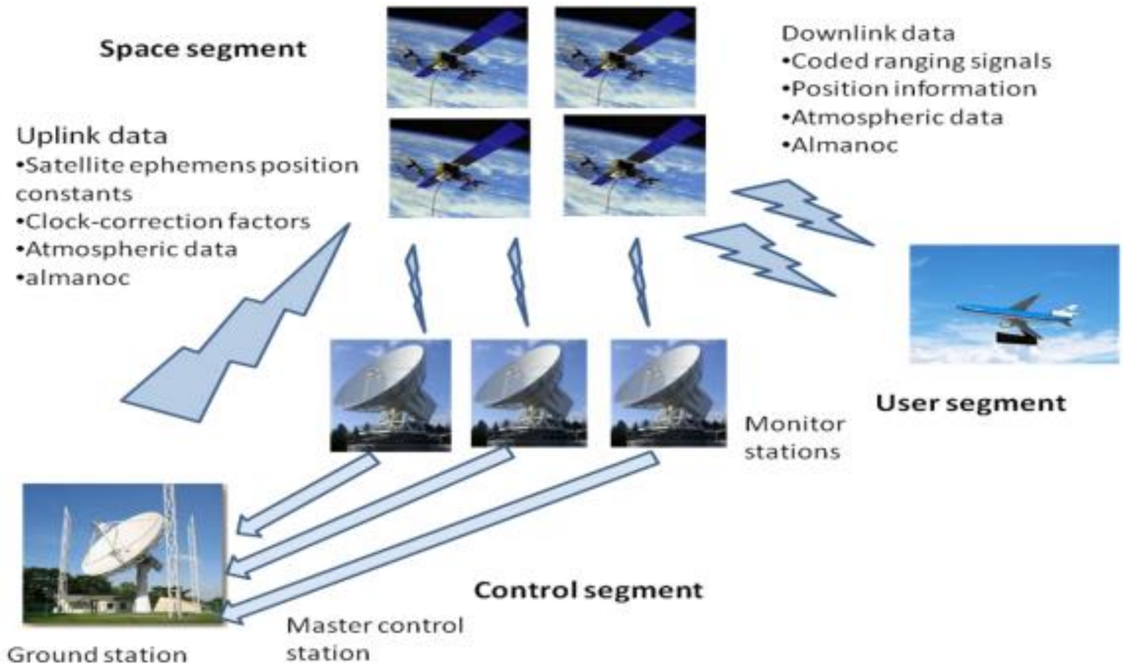


Fig. 1.17 GPS segments (Source: Wang, 1999)

Geographical Information System (GIS)

In the highly dynamic and complex world 'information' has become a critical resource for effective and efficient management of organisation. Information Technology in its various forms is enabling organizations to churn raw data into meaningful information for effective decision making. One such form of Information Technology (IT) is Geographic Information System (GIS). It is described as: "An organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information". According to this definition and as shown in Figure.1.18, GIS includes not only computing capability and data, but also manages the users, and organizations within which they function and institutional relationships that govern their management and use of information. GIS system design and implementation planning are not a separate process. They must occur in conjunctions with one another (Wang, 1999).

Elements of GIS

The major elements of GIS are geography-the actual location, information- the description of the location, and the system to integrate and perform the required GIS functions.

i. Geographic: The system is concerned with data relating to geography and geographic scales of measurement. This is referenced by some coordinate system to locations on the surface of the earth.

ii. Information: The system allows for the storage and extraction of specific and meaningful attributes information. These data are connected to some geography and are organized around a model of the real world. Spatial and non-spatial queries are made possible (Wang, 1999).

iii. System: An automated system should include an integrated set of procedures for the input, storage, manipulations and output of geographic information. GIS is an integrated single platform of three areas viz. the relational database management system to store spatial and non-spatial data; cartographic capabilities to depict, graph and plot geographic information; and spatial analytical capabilities to facilitate manipulation and spatial analysis(Wang, 1999)..

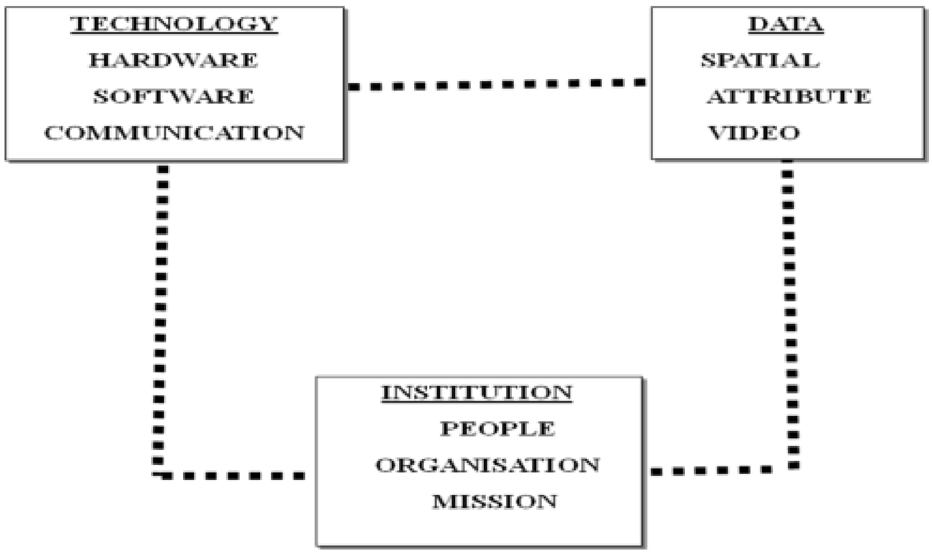


Fig. 1.18 Domains of GIS (Source: Wang, 1999)

Components of GIS

There are four components of GIS: (1) data, (2) hardware, (3) software, (4) methods and (4) people. As shown in Figure 1.16, the components must be integrated to support the management and analysis of spatial or mapped data. Data tends to be at the center of any GIS system, while the computer components of the system support the data management and analysis (Wang, 1999).

Fig. 1.19 Components of GIS (Wang, 1999)

Door to Door Garbage Collection- An initiative of Shimla Municipal Corporation and SEH B Society
Location: Shimla

Main Players: Shimla Municipal Corporation, Shimla Environment Heritage Conservation and Beautification (SEHB) Society

Year of Start: 2010

Approach: Shimla, the capital city of Himachal Pradesh with a strong cultural heritage and panoramic scenic beauty is amongst the famous tourist destinations in India. Due to rapidly growing population and poor infrastructure towards the end of 19th century, the hygiene, sanitation and public health became a cause of concern for the city. The initiatives taken by Municipal Corporation to deal with the solid waste menace and overall situation remained largely unsatisfactory wherein SMC undertook three door to door collection initiatives involving various NGOs, voluntary organizations to collect waste from the households from 1999-2008. However, the concerns raised by local people that was followed by a writ petition, resulted in the High Court of HP issuing directions to improve the MSW system. Subsequent to the directions of the High Court, the State Urban Development Department notified door-to-door collection initiative for Shimla in 2006. This led to the establishment of SEHB society registered under the Himachal Pradesh Societies Registration Act in 2009.

Under this initiative the following approach was adopted for bringing about significant improvements in solid waste management system:

Institutional & Managerial:

- ✓ The SEHB Society's waste collection initiative is headed by the Municipal Commissioner with responsibility of overall supervision by the Corporation Health Officer as member secretary of the society. Collection and transportation services are looked after by the SEHB staff which is supervised by the Chief Sanitary Inspector.

- ✓ A dedicated team has been allocated for smooth functioning of the system. Every ward has a dedicated Supervisor and assistant supervisor with 2 coordinators looking after all 25 wards and reporting to the Sanitary Inspectors.

A mechanism for collection was defined through a methodology of physical verification for households and communities.

- ✓ Optimization of routing of each vehicle and provision of substitution plan for any breakdown in vehicles was established Centralized complaint redressal system within MCS and dedicated telephone lines at SEHB office were established to resolve the complaints of users. Feedback registers are updated on daily basis.
- ✓ Regular monitoring by the Health Officer and Sanitary Inspectors as well as prearrangement/ substitution of the workers to maintain the efficiency and absence from work
- ✓ Effective and timely remittance of salaries of the field staff
- ✓ Shimla Municipal Corporation provided Identity cards to SEHB Society's workers and also provided EPF and ESI benefits to all registered SEHB workers.
- ✓ Regular health checkups of garbage collectors Woman participation was encouraged

Legal:

- ✓ Introduction of door to door collection bye laws with special mandate for citizens to handover the municipal solid waste to SEHB society, the agency authorized by SMC
- ✓ Introduction of user charges by SMC and its provision within the bye laws for compliance.
- ✓ Introduction of penal provisions for non- compliance by citizens like littering and non-participation in the door to door collection system.

IEC:

- ✓ For increasing community participation in this initiative, SMC organized community meetings to disseminate the details of the collection system and its functioning.
- ✓ Mass (jingles for radio channels, local advertisements)and print media was used to further promote the initiative and sensitize people.

Ward level lucky draw for registered users

- ✓ Distributing society's annual calendar to the households with all necessary information and messages
- ✓ Documenting and dissemination SEHB's case study and brochure for further outreach and sensitizing people for the initiatives taken

Outcome:

- ✓ More than 90% of coverage in 25 wards and collection of waste from the households
- ✓ Effective and timely redressal of complaints by the ward supervisors for non -delivery of service
- ✓ Compliance with laws pertaining to the MSW Management
- ✓ Overall environmental improvement and aesthetic value of the city
- ✓ Manual on Less incident of monkey nuisance and conflict

Success Factor:

- ✓ A strong political and administrative will to improve the MSW system in the city
- ✓ Strategic planning and revisiting/ assessing the existing situation
- ✓ Intensive campaigning and interaction of officials with citizens regarding the proposed door to door collection system
- ✓ Effective monitoring and follow up by officials
- ✓ Penalty provisions for littering and non-compliance in the door to door collection

system through Bye laws.

Overall Sustainability:

- ✓ Collection of user charges has resulted in the financial sustainability of the project.
- ✓ There has been a steady rise in the user charges collection during the last financial year.
- ✓ A dedicated team has been appointed for maintaining the regular cash flow essential to meet the salaries and operational liabilities of the self- financing scheme.
- ✓ Strict monitoring is carried out to ensure the collection and also the planning of surplus for overhead expenditures
- ✓ Wife working in same wards

Summary

Waste Management needs societal support, manpower, equipment and technical expertise. The intention is to safely transport the waste from the source to a common area, remove as much re-usable, recyclable, compostable components and energy out of it and reduce its volume before safe disposal. The waste dumps must be carefully managed to prevent pollution, before being scientifically capped with good soil and put to alternative use. Geographical Information System and other technologies like RFID, GPS etc. can be used as a decision support tool for proper planning of solid waste management.

Model Questions

1. Explain logistics and waste management
2. Discuss on Equipment, transport, RFID and cloud based waste management
3. Discuss on waste segregation. Compare 2-bin and 3-bin models
4. Explain on compaction, W to E landfills and dangers involved.
5. 5.If you are a solid waste collection manager of a small town, what equipment will you need for operating effectively?
6. Briefly explain the steps in waste management.
7. What are the social aspects to be considered for a successful waste management programme?
8. Explain GPS and GIS and its application in waste management.

To Do Activities

1. View film on the waste pickers.
2. Discuss in class how the condition of waste pickers can be improved. In an ideal world, what kind of job opportunities would they like to give to the downtrodden if they themselves had a waste processing company?
3. View film on Floral Waste.
4. Visit/ survey of city's waste management. Facilitate students to identify gaps from a logistic point and enable them to analyse the reports.
5. Read Case study on festival waste and watch film. Is there a pilgrim spot or festival that generates large amounts of waste during a short period of time? If so, organize a field visit to the location. This visit can be scheduled to coincide with the event. Other sources of pollution (such as air and noise can be studied. Also water sampling, volunteering for a clean festival, etc can be encouraged).
6. Watch film on Ontario's recycling unit to understand the difficulties caused by improper segregation.

7. Organize a field visit to a transfer station. Observe the sorting. Make students participate in sorting of waste, with permission of authorities and proper safety equipment.
8. Film viewing of Nashik's and Pune's waste management. Followed by classroom discussion between their field experience and the information from the film.
9. Show film on Sanquelim Mine reclamation.
10. Discuss steps in Capping. Use Jawaharnagar Case Study.
11. Visit a waste management facility. Conduct an exercise in waste segregation – wet waste, dry waste. Interview a waste handler- from the municipality, self-help group or waste-picker. Find out the practical issues they face during the course of their daily routine.
12. Discuss on what topics each student is interested in, scope out possibilities of career development, research or internship opportunities.

Films

a. Waste Picker's life and livelihood. Duration: 11 min.
https://www.youtube.com/watch?v=aLda8O2ySMc
b. New life for waste flowers, Duration 6 min.
https://www.youtube.com/watch?v=Boogipm_9Qg&feature=youtu.
c. Film: Sabarimala temple a shining example of 'Swacch Bharat Abhiyan': PM Modi - ANI News Duration 2 min.
https://www.youtube.com/watch?v=8HEyBZ1LpHY
d. Indore waste collection: Duration: 8 min
https://www.youtube.com/watch?v=V98Pbum1wQA
e. Tour of London's (Ontario) recycling Centre.
https://www.youtube.com/watch?v=c2Tr-U0nALM
f. Street sweeping RAVO 5 series sweeper, Duration 4 min
https://www.youtube.com/watch?v=3p1M1C2gYsg
g. Sarthak Indore: Plastic Waste Management project -Movie made by UNDP Duration 2min.
https://www.youtube.com/watch?v=7NwpQUw9gIs
h. Importing garbage for energy is good business for Sweden, Duration: 4 min.
https://vimeo.com/103801887
i. Nashik Waste Management, Duration: 6 min:
https://www.youtube.com/watch?v=JXmDJtJ-mMw
j. Sanquelim Reclamation Mines - Vedanta Sesa Goa Initiative, Duration 9 min,
https://www.youtube.com/watch?v=5zJtHnEXLUM

Chapter 2- Collection and Transportation

Introduction

Waste collection methods vary widely among different countries and regions. Domestic waste collection services are often provided by local government authorities, or by private companies for industrial and commercial waste. Some areas, especially those in less developed countries, do not have formal waste-collection systems.

Objectives

- To understand fundamentals of GIS and GPS
- To understand economics of recycling
- To understand reverse logistics in waste management

Structure

2.1 GIS and GPS in waste management

2.2 Dynamic Vehicle Routine and scheduling

2.3 Route Optimization, scheduling- fleet management

2.4 Categorization of waste recycling

2.5 Economics of recycling

2.6 Best Practices for Reverse Logistics Management

2.1 GIS and GPS in Waste Management

Solid waste has been the biggest concern for Municipal authorities. This solid waste is creating serious health issues and also disturbing the balance of the environment. The traditional way of managing and monitoring the waste collection from bin to bin and doing everything manually is a very complicated and tough process and here probability of getting wrong information is more. Thus, the need of a robust solid waste management system arises, where an authority can get information right from filling of garbage bins, picking up of bins by the waste collecting vehicles and movement of those vehicles to the waste dumping sites.

ICT Based Solid Waste Management System

Our One of the key components of the undertaking is an ICT based solid waste management system. In the scenery of provoke progression, information and communication technology (ICT) has turned into an inescapable part to plan and structure of present day solid waste management (SWM) systems. This study shows a basic audit of the current ICTs and their utilization in SWM systems to unfurl the issues and difficulties towards utilizing coordinated advances based systems. The major subject of the project is an ICT based Solid Waste Management and ICTs are isolated into four classes, for example, spatial innovations, ID advances, information securing advances and information correspondence advances. There is a need to push our waste management system from linear to circular economy.

Management Information System

A comprehensive monitoring and evaluation system should be adopted for assessing progress towards meeting the targets in the MSWM Plan and for monitoring successful implementation of the plan. The monitoring system adopted should:

- ✓ Collect data regularly, and
- ✓ Analyze collected information, take/propose corrective measures, and support the planning & implementation process.
- ✓ Collection and analysis of data related to solid waste management is required to assess the existing situation and propose adequate measures to improve service delivery. A
- ✓ Management Information System (MIS) can retrieve relevant information which can then be used by decision makers.

MIS assists in monitoring the efficiency of SWM systems. It increases transparency and accountability of officials in the solid waste management system. It helps in establishing a strong and reliable information data base necessary to facilitate planning, mid-course corrections and decision making. Geographic Information Systems (GIS) and visual capture of information using cameras are now being integrated with the MIS to provide spatial and visual validation for provision of services.

Communication technologies such as Radio Frequency Identification (RFID), Global Positioning System (GPS) and General Packet Radio System (GPRS) are now integrated with Geographic Information Systems (GIS) for monitoring the solid waste management system. These can be suitably adopted by cities to improve the efficiency of service.

Computer application of mentioned tools need some prior data/information to provide correct information to decision makers. Figure 6.1 illustrates prior data requirement for computer application of MIS-GIS-GPS system.

Integrated Technologies

Management Information System (MIS)

It is a typical computer based system used to manage information about the operation, which is important for decision making. A MIS (Management Information System) can manage large amount of spatial and attribute data such as type of waste, vehicles etc. It provides concise, correct and timely information to decision makers.

Radio Frequency Identification (RFID)

RFID tags are designed to enable data capture by electronic readers, which then transmit this information via a wireless network to the MIS. These tags are pre-loaded with information related to the physical location to which they are attached. Auto-ID technologies have been used to reduce the amount of time and labor needed to input data manually and to improve data accuracy. Predominantly, RFID tags are used to identify secondary collection bins and help monitor their pick-up and evacuation atthe treatment/processing/disposal site.

Global Position System (GPS)

GPS is a satellite-based navigation system which records geographical/physical locations on the earth. The satellites periodically emit radio signals to GPS receivers, based on the identification and reflection of these signals, GPS are used to calculate distance and to compute two-dimensional or three-dimensional position. GPS is used for tracking the position of trucks and bin locations.

General Packet Radio System (GPRS) Technology

GPRS is a wireless data network system which achieves real-time sending and receiving of data. The GPRS technology helps transfer data from remote devices to centralized data integration and management systems.

Geographic Information System (GIS)

GIS integrates software and hardware for collecting, managing and analyzing spatial and attribute data in a computer-based system. It helps to analyze spatial and related attribute data to identify patterns, trends and relationships. GIS systems help in planning waste transportation routes and locations for waste collection bins. Linked with RFID and GPRS systems, GIS provides real time, data on vehicle, collection of waste, bin pick up and transportation to treatment/disposal systems.

A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions. In today's fast-paced society, customers demand service and products sooner than ever. Companies offering delivery services are finding they need to provide quick deliveries and accurate time windows. While companies struggle to meet these demands, they also must weigh their costs for services since mobilizing workforces can be an expensive endeavor in both assets and personnel resources. Small companies and Fortune 500 companies alike are finding that ESRI's GIS software for mobile resource planning is critical to meeting these goals. They are discovering how ESRI software makes it easier to improve business operations so they can get the right goods and services to the correct place at the appropriate time for the least cost. Transport operators, logistics companies, and service engineers are realizing major improvements in operational efficiency, cost reduction, and resource deployment. Using a GIS-based, geographically focused logistics package allows users to Calculate realistic travel times and distances between stops, deliveries, and depots. Improve work area balancing, work scheduling, and route optimization. Create more realistic and accurate routing and scheduling plans that consider natural barriers, street-level travel times, traffic flows, and holdups.

Use of integrated technologies such as MIS, GPS and GIS has resulted in the development of integrated and comprehensive solutions for SWM. Beneficial uses of these systems include (Fig. 2.1):

- ✓ Data aggregation and process monitoring is managed electronically, avoiding day to day human intervention, thereby increasing reliability and transparency of information.
- ✓ Movement of vehicles may be monitored on real time basis by using a surveillance system based on GPS/GIS communication technologies, thereby reducing noncompliance and enhancing efficiency.
- ✓ Status of evacuation of bins on a daily basis can be monitored, facilitating increase in service efficiency.

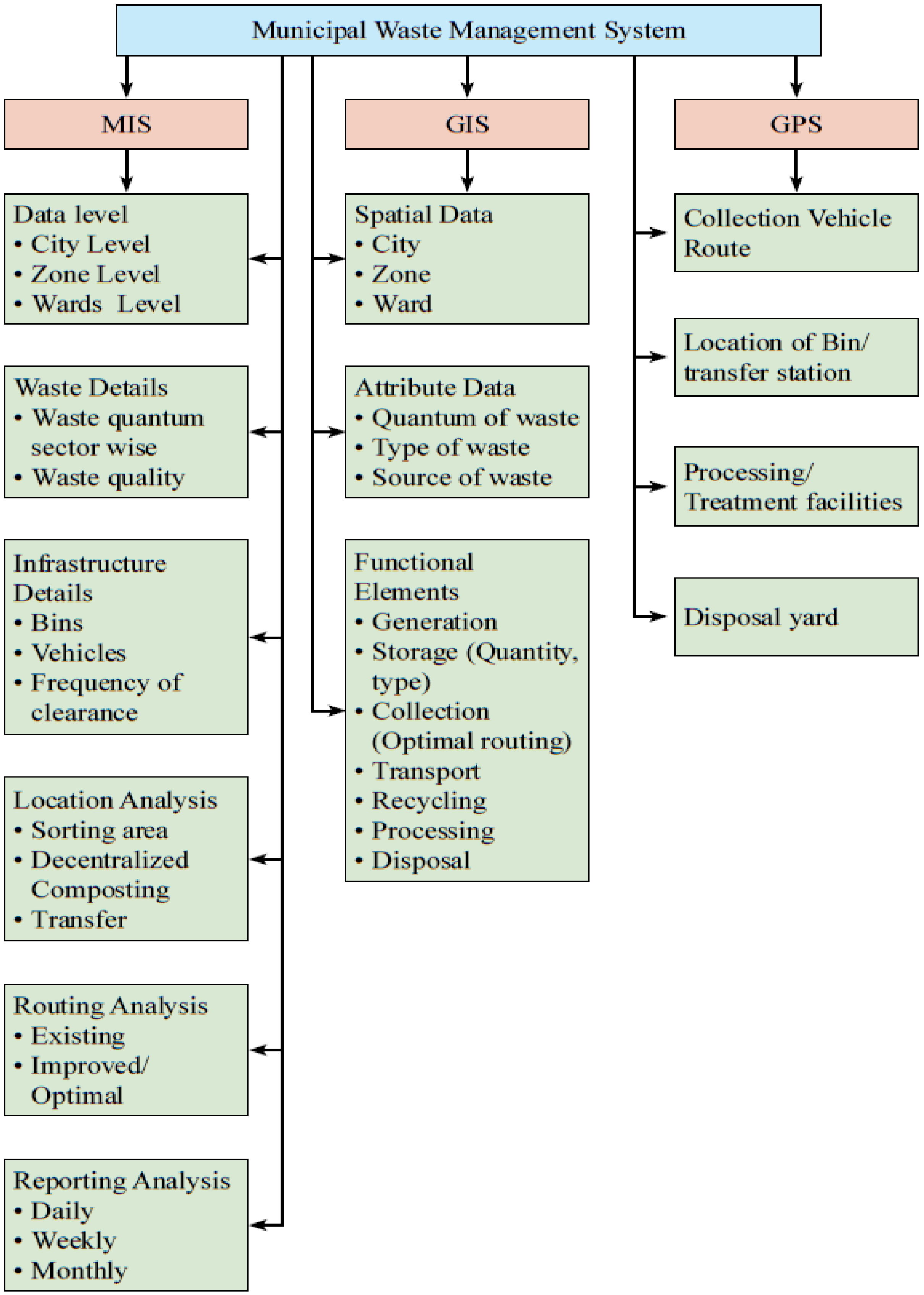


Fig. 2.1 Minimum Data Requirement for MIS-GIS-GPS Systems (Source: GIS best practices, 2007)

Integrated Technologies (MIS, GIS, GPS, and RFID) for Monitoring Solid Waste Management:

Real time monitoring of status of bin clearance, estimation of amount of waste in and around bins, surveillance of movement of vehicles, optimization of routes and reallocation of bins according to the estimated waste, are possible through integration of several technologies, hence providing transparency in civic administration. Figure 2.2 indicates integration of various technologies for solid wastes monitoring and management.

Each container is equipped with an RFID label having a unique identification code. Low frequency passive tags are proposed because they offer long term low cost solutions and are operational in extreme conditions resistant to environmental hazards. Geo-coding of containers is done manually through field visits and by noting the locations using a GPS receiver. When the container gets loaded onto the truck, the reader reads the serial number of the tag on the container. At the same time, the GPS receiver on the truck calculates its location using satellite data. The serial number of the tag, location, date and time are transmitted real time via the GSM network to the communication gatewayof the control server. The same is repeated when the truck reaches its destination. After data processing, information is transferred to the GIS terminal. Real time information can be shared with clients via a web-based solution.

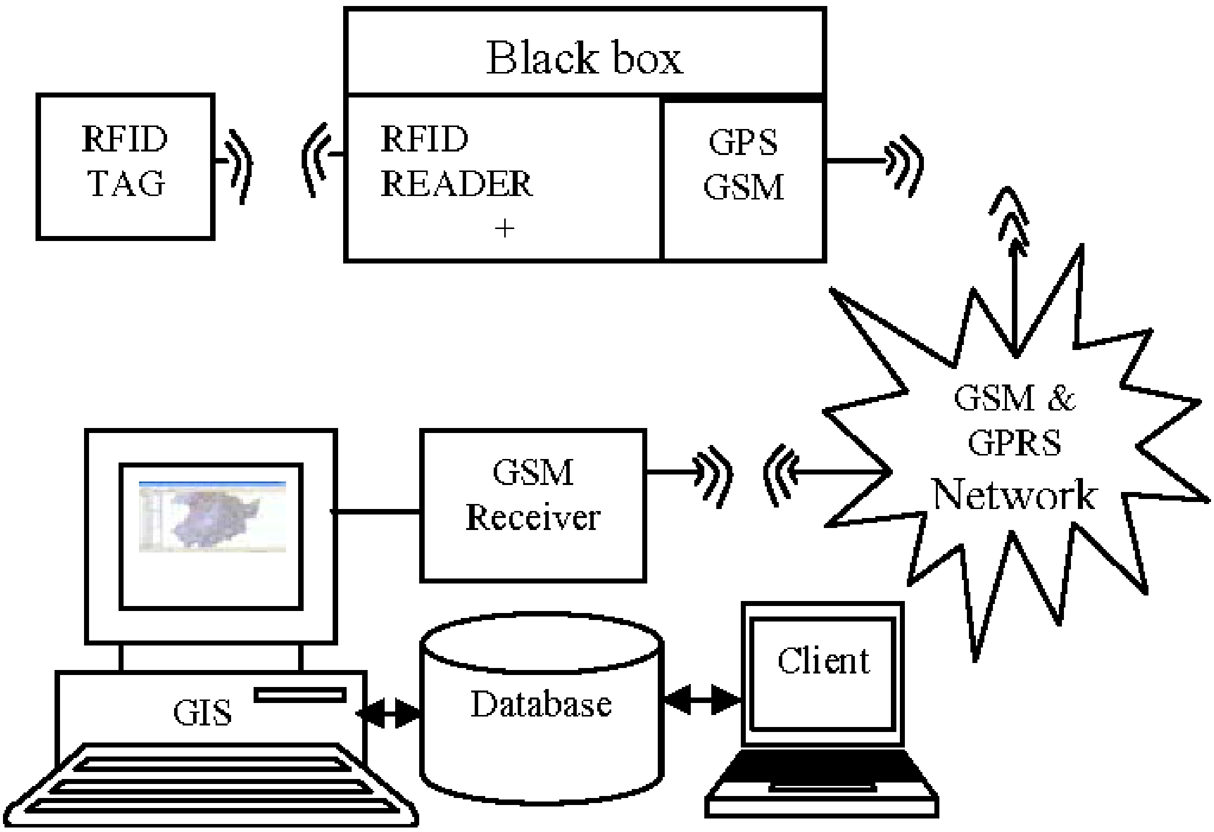


Fig. 2.2 Solid Waste Monitoring and Management System (Source: GIS best practices, 2007)

Case study:

Pimpri-Chinchwad Municipal Corporation (PCMC) has initiated the task of monitoring its SWM services through the use of Information and Communication Technologies (ICT):

By deploying GPS based real time vehicle tracking system, PCMC is able to:

- Monitor the actual movement and real time position of the vehicle
- Monitor the movement of collection vehicles
- Improve service delivery mechanism and achieve better information management
- Ensure citizens' participation in governance mechanism for overall improvements in collection efficiency
- Reduce unwanted trips/detours/stoppages thereby enhancing the productivity/ utilization of the fleet
- Generate MIS report on daily basis to take informed decision.
- PCMC published the "Bin Pick up Status" on their website to inform citizens and encourage them to monitor bin pick-up status in their localities.
- This endeavor resulted in improving PCMC's accountability and also offered a reliable tool to facilitate data provision under the Right to Information Act, where such information is sought.

Case study:

Effective monitoring of collection and transportation of municipal waste through GPS (Global Positioning System)

Year of start: 2011

Main players: Nashik Municipal Corporation (NMC) - Health Department and Computer Department.

Approach: Door to door collection of waste in the city was established through Ghantagadis (designated waste collection vehicles) in 1998. With the start of the JnNURM project, the Nashik Municipal Corporation received central funds for strengthening the existing system resulting in the procurement of 124 Ghantagadis and GPS systems under the project. GPS machines were fitted on each vehicle in order

to improve the collection and transportation efficiency of the vehicles. An agency was appointed by NMC for installation of the GPS system (machines and software) and its operation and maintenance. A Cell (centralized monitoring unit) was formed at the NMC office to manage and supervise the overall system - like monitoring and tracking of vehicle movement on a regular basis, for tracking of complaints and inefficiencies and for the generation of daily and weekly reports. The redressal of complaints which

were generated was done with the support of the sanitary inspectors at ward level.

Outcome:

Installations of GPS zzsystems on all 124 Ghantagadis owned by NMC and centralized monitoring unit created at NMC headquarter. Skill development and capacity building of the ground staff and contractors engaged in collection of solid waste was undertaken when the system was introduced.

Ensuring that the time delay and average stoppage time (4-5minutes) for each vehicle was tracked.

Effective and timely redressal of complaints generated through the GPS monitoring system by the ward level sanitary staff.

Generation of daily, weekly reports by vehicles to ensure adherence to the timing and collection of the waste at the respective collection points.
Information transparency and data availability on the public domain for citizens and public representatives with respect to the routing and timings of the vehicles increased confidence in the system.

Success Factor:

- Proactive role of NMC to streamline and monitor the collection and transportation system.
- Capacity building of the NMC staff, contractors, vehicle drivers and workers prior to the installation of the system.
- Collection of waste at a given stipulated time by the contractors
- The real time report generation through GPS helped in resolution of disputes between citizen's, officials and contractor thereby creating a transparency between the consumers and service providers
- Regular monitoring of the reports by the Commissioner and the Health officer resulted in the improvement in the collection and transportation efficiency.

Overall Sustainability:
By appointing an operator for regular Operation and Maintenance of the GPS system, NMC has insured that the GPS machines and the monitoring system is functional and the initial teething troubles faced by NMC of dysfunctional/ destruction of GPS machines installed in the Ghantagadis, was overcome. The pro-activeness of the Commissioner and the Health Department of NMC towards transparency in the management of the MSW in the city ensuring the sustenance of the system.

2.2 Dynamic Vehicle Routine and scheduling

Economic growth and increased urbanisation has led to increased personal travel and transportation of goods within cities which has caused many environmental and social problems, i.e. air pollution, accidents and noise, as well as economic problems, such as increased of production costs, travel time and energy consumption. With limited funds and space available for new road infrastructure, there is a real need for road authorities and users to adopt more sophisticated procedures for efficiently using existing transport systems. Vehicle routing and scheduling (VRS) is a major and established area of operations research, Procedures have been developed for determining the routes and or schedules for freight or passenger vehicles so that the individual or total indices (travel time, travel cost, travel distance, etc.) are optimised, while various requirements (constraints) are met. Improved performance of distribution systems has resulted from the application of such procedures (Yang, 2017).

VRS can be classified into two categories: static and dynamic. A VRS is "dynamic" if information relating to the problem is made known to the decision-maker or is updated concurrently with the determination of the set of routes or schedules. By contrast, if all inputs are received before the determination of routes and schedules and do not change thereafter, the problem is termed "static". Static VRS procedures have been extensively researched in the past. However, there have so far been limited investigations into procedures for dynamic VRS since there have been many technological obstacles that have inhibited their implementation. Recent developments in transportation and logistics, particularly the areas of Intelligent Transport System (ITS) and Just-in-Time (JIT), are making dynamic vehicle routing and scheduling more technically feasible and attractive. The application of advanced information and communication technology through ITS has the potential to enhance the mobility, safety, environmental quality, and productivity of transport systems. With the growing use of "Just-in-Time" transportation there are increased requirements on carriers to increase performance as well as flexibility (Yang, 2017).

Moreover, the rapid advances in related technologies, such as computer systems, communication networks, Electronic Data Interchange (EDI) and Global Positioning Systems (GPS) has led to a renewed interest in researching and implementing dynamic vehicle routing and scheduling systems. Dynamic VRS is an information-intensive decision making process that integrates data from the public or private sectors involved in daily vehicle operations In the case of urban freight transportation, these could be road or municipal authorities, freight carriers l/ drivers, customers or retailers, etc. Geographic Information Systems (GIs), were in past limited to the function of digital mapping in VRS, but now they can be extended beyond traditional databases and integrated with many other types of information, i.e. management or statistic data, smart maps and analyses GIS can now perform a major role in spatial information based complex decision support systems (DSS) as VRS and. In this context, a well devised information integration framework will be of great benefit in achieving the realization of a feasible system. Such a framework needs to include a description of the problem formulation, how uncertainty will be handled and how optimal decisions will be made.

2.3 Route Optimization, Scheduling- Fleet Management

By augmentation of the Global Positioning System (GPS) with other satellite or land-based navigation monitoring methods, we can acquire precise positioning of any point where a receiver or an antenna can be planted. This precise positioning data can be made meaningful and can be put to various uses through integration with Geographic Information Systems (GIS), which have various forms of data organized as layers of information (Prakash and Kulkarni, 2009). The GIS can integrate the various data layers and present the same from different perspectives, which are pertinent to the problem at hand in a manner that best appeals to human perception. Fleet management addresses the problem of managing fleets of trailers, containers, boxcars, taxi-cabs, locomotives, business jets and other modes of public transport. Such operations of management of a fleet of vehicles require solutions to various problems like dynamic assignment, trip allocation, dynamic routing, responding to real-time customer demands and dispatch instructions, automatic vehicle location (AVL), trip and freight reporting and monitoring driver and vehicle characteristics to attain efficient and optimized performance with available resources. Owing to the tough competition among transportation companies, fleet management problems with their implications of logistics and optimization are vital issues to be attended to for achieving the best possible performance and maximum profits. GPS-GIS integrated systems provide vital data in a graphic form that is easily comprehendible by the drivers, customers, fleet operators and fleet owners. The data that is provided by these systems is then fed to the logistics and optimization software that various fleet operators use to manage their operations (Yang, 2017).

GPS Augmentations

Various methods have been explored as augmentations to GPS signals to derive continuous precise positioning on GIS-based maps, which is vital for fleet management applications. A few have been discussed below (Prakash and Kulkarni, 2009).

(1) Differential GPS: This method is used to minimize errors in positioning by mutual comparison of current data and previously known data for a base station and applying the corresponding correction to the rover station. This correction can be applied in the following 2 ways:

- The 'Block Shift Technique' uses the computed coordinates at any time and compares them with the known coordinates of the base station. The error, which is in terms of a correction in coordinates, is applied to the rover. This method requires essentially that the two positions be found using the same set of satellites.

- The 'Range Correction Technique' uses the instantaneous and known base station coordinates to compute the error in all pseudo-ranges. Since, this correction is computed for all pseudo-ranges, this method gives the flexibility to the rover receiver to use whichever satellites it wants to compute the corrected coordinates (Yang, 2017).

(2) **Beacons and Antennae**: These are used along routes where GPS signals are hard to receive or are faced with multi-path problems due to tall buildings, canopy or terrain conditions. These instruments detect the presence of the vehicle along the road and relay information to the control station to help track the vehicle even during loss of GPS signals. They can also be placed inside long tunnels where tracking becomes very difficult and loss of signals for a long time cannot be afforded (Prakash and Kulkarni, 2009).

(3) **GLONASS and Galileo Integration**: The GLONASS is a system similar to the GPS and was established by the USSR (now the Russian Federation). The Galileo is a similar system being developed by the European Union, to be functional by 2008 (Rizos, 2000). The integration of GPS with these systems is favourable because they complement each other and can provide good accuracy on integration. Other benefits are multiple frequency allocations, better geometry and large number of available satellites and hence greater reliability of data (Han, 1999).

(4) **Pseudolites**: These are ground-based pseudo-satellites that transmit GPS-like signals and can be used as substitutes for space-borne satellites when their signals are hard to track. They are normally located on high buildings or hills from where they can track vehicles just like a normal satellite would do in absence of obstructions and are also free of ionospheric and tropospheric errors that are faced by GPS signals. The pseudolites then transmit signals to the control station to allow continuous tracking of vehicles even in difficult terrain like deep open-cut pits and mines and downtown urban canyons. Inertial Navigation Systems (INS) like gyroscopes and accelerometers have also been used in integration with GPS signals and perform to a better level of accuracy when coupled with pseudolites. A problem faced by pseudolites is the multi-path error due to their location close to the ground. To resolve this problem, High Altitude Platform Systems (HAPS) have been amongst the research projects taken up by many countries. Japan has been investigating the use of an airship system that will function as a stratospheric platform (at a height of about 20 km) above the ground

for applications in communications, broadcasting and environment monitoring. The possibility of these airships being equipped with pseudolites to provide centimeter level accuracy is being explored in Japan (Tsujii et al., 2002).

Types of Fleets and Associated Problems

(1) Public transport and Utility fleets: Public transport includes bus services, trains, trams and private fleets of hotels, airlines and educational institutions. Utility fleets cover fire brigades, police vehicles, ambulances and other fleets that are on standby in case of emergency or disasters. It is extremely necessary for fleet operators to track their vehicles in unforeseen cases of accidents, thefts or hijackings. For any public transport organization, scheduling and planning of routes and ensuring that the vehicles run as per schedule is vital. Failure in management of fleets that make large number of repetitive trips in larger cities cause the system to become unpopular among the masses and results in a shift in traffic towards personal modes of transport. In conventional systems, tracking used to be done by posting traffic controllers and time-keepers along the route. This does not provide complete coverage and also is error-prone due to human dependability. The paperwork too is very cumbersome to handle and analyze. A good example of implementation of GPS-GIS systems in India is the case of the Bangalore Metropolitan Transport Corporation (BMTC), which installed indigenous GPS units on all buses of a depot. The readings were downloaded every three days and reports were drafted with emphasis on missed trips, short trips and punctuality problems (Kharola et al., 2002).

GPS-GIS integrated systems provide the operators with location, speed, distance traveled in a certain time and time taken to complete trips, which can be used for automatic billing to make payments in case of hired private vehicles and for assessment of performance of the fleet to ensure public comfort. In case of utility fleets, when a customer calls the control center for service, the operator can easily see the availability of the vehicles near the customer's area on a map. The individual drivers have different colour codes showing their status of job which is used by the operator to assign the new job immediately through an electronic message via the Global System for Mobile Communication (GSM) network without the need of waiting for the driver to establish verbal contact. The GPS-GIS system also monitors idling vehicles and precise destination locations for devising shortest paths for total coverage (Prakash and Kulkarni, 2009).

(2) Commercial Fleets: The freight transportation industry is facing severe competition with a large number of organizations venturing into the lucrative goods transport and logistics sector with increasing economic growth. Businesses are flourishing and the supply of raw materials to the manufacturing plants and the finished goods to the consumers in limited time with minimum requirement of storage at warehouses is becoming a vital challenge. Fleet owners must have real-time information about the location and status of all their vehicles for dynamic scheduling and planning of trips that originate as a result of dynamic consumer requests.

Logistics and Supply Chains

Requests from customers of commercial fleets arrive randomly over time and require service within a short interval of time. Since, it may take upto several days to move transportation equipment over long distances, it is not advisable to wait until a customer request is known before starting to move the equipment. Among the randomness of transit times and equipment failures, it is necessary to wisely move equipment to serve demands before they are known (Powell and Topaloglu, 2002).

Truckload motor carriers in specific have to take care of carrier requests and place dynamic orders for delivery and pick-up. The equipment and cargo to be carried must be decided and the protocol planned. If a cargo needs to be taken through a long distance, it may go thorough the hands of several drivers and may have to take breaks at warehouses on its journey to the destination. After a driver completes his segment of the trip, it is the fleet manager's duty to get him another task that will carry him back home or ask him to wait till a demand is created in that area. These complex components of commercial fleet management – supply and demand management and logistics (strategic movement, storage of materials, parts and finished goods on supply chains through stages of procurement, work-in progress and final distribution) require real-time visual positioning of all vehicles that can be very effectively done by a GPS-GIS system. The fleet operator can use data from such systems for optimizing his operations by visual monitoring and dynamic routing of his fleet (Prakash and Kulkarni, 2009).

Disaster Relief and Recovery Operations

One of the most important applications of fleet management is in immediate dispatch of relief to disaster-struck areas. GPS-GIS systems can be used to plan evacuation routes and to design centers for emergency operations. During the relief process, these systems help rescue operations in areas where the communication networks have been destroyed. A case worth discussing is the erratic traffic condition immediately following a landslide or an earthquake. The Laboratory of Geodesy at the School of Engineering of the Aristotle University, Thessaloniki at Greece has developed a system of fleet management working with real-time DGPS. The objective after an earthquake is to make an assessment of traffic conditions for easy and quick movement of relief vehicles to the site of disaster. The constraints are loss of earlier uniform accepted data of normal traffic conditions on various routes, which go invalid after disruptions due to the earthquake or landslide. The system developed at the Aristotle University assumed utility vehicles like fire engines, ambulances and other emergency vehicles to be at different locations in the area and by monitoring their real-time positions after the disaster, a real-time database of the current traffic conditions is built and is used to guide relief vehicles through the least congested routes providing shorter access times using the GIS database (Savvaidis et al., 2000).

The effectiveness and success of the GPS-GIS integrated systems for fleet management is evident from the cleaning-up operation taken up at 'Ground Zero' after the World Trade Center disaster on the 11th of September 2001. After the devastation, the city of New York was faced with the overwhelming task of removing more than 1.8 million tons of debris from the site. The continuing search for human remains and processing the debris as evidence further complicated the clean-up effort. A GPS-GIS solution was sought for the management problem due to the extensive scope of the project with costs that threatened to overwhelm existing resources. Criticom International Corporation of Minneapolis, Minnesota used a broadband communications network, a camera monitoring and time-lapse recording system, a GPS-based vehicle tracking system and Internet services to access various GIS databases for achieving the task. Debris hauling was started under a paper-ticket system, which was quickly replaced by installation of GPS receivers on 235 trucks that were used to carry the debris to various locations. The tamper-proof GPS receivers were designed to send alarms to the control center in case of signal loss, trailer disconnection, tampering, deviation from pre-determined routes and ensured safety and prompt delivery and dispatch. The real-time information from the receivers was used to develop an electronic system that had features of record-keeping, tracking-data storage and billing and other details about each truck, the driver, the debris type carried and destination. The GIS-based maps on the computer screen at the control station displayed real-time positioning that made it possible to plan intervals at which trucks were ready to load, dump and return for reloading. This prevented long queuing of trucks at the site and helped prevent traffic bottlenecks there. The data of truck-time spent in queues, total travel time and loading time stored in the GIS database could be used to substantiate claims and resolve disputes and helped to improve the efficiency of the operation. The GPS-GIS system had an important feature called 'geofencing' that prevented deviations from the given dispatch routes. The system used the exact defined routes and location of tunnels in the GIS to sense the proximity of a tunnel and automatically lowered tracking levels for the period when the particular truck was near and in the tunnel to prevent loss of signal (Prakash and Kulkarni, 2009).

This was the first time GPS technology was used in a disaster recovery setting and it gave remarkable results. The integration with GIS provided enhanced security and efficient management of operations by more than tripling the number of loads per truck per shift over the initial paper-ticket system. The removal project that was estimated at $ 7 billion by city officials was achieved in just $ 750 million. The task was completed in an amazing duration of just 8 months and the audit data and other information were kept online for the trucking companies even after the system was closed (Menard and Knieff, 2002).

2.4 Categorization of Waste Recycling

Importance of Recycling

Recycling is important in today's world if we want to leave this planet for our future generations. It is good for the environment, since we are making new products from the old products which are of no use to us. Recycling begins at home. If you are not throwing away any of your old product and instead utilizing it for something new then you are actually recycling. When you think of recycling you should really think about the whole idea; reduce, reuse and recycle. We've been careless up to this point with the way we've treated the Earth and it's time to change; not just the way we do things but the way we think (Recycling guide, 2003).

We should recycle because

- To Make Environment Clean
- Conservation of Materials
- To Save Energy
- Reduce Garbage in Landfills

Recycling is good for the environment, in the sense, we are using old and waste products which are of no use and then converting them back to same new products. Since we are saving resources and are sending less trash to the landfills, it helps in reducing air and water pollution. Energy saving is important if we are to reduce the future effects of global warming. If we recycle one aluminum can, we are able to save enough energy to run a TV for around 3 hours. This will obviously depend on the energy consumption of your TV, but it gives you a great idea as to just how much energy can be saved during the process of recycling products (Recycling guide, 2003).

It is believed that (the U.S.) cut approximately 40 million newspapers each day, leading to the equivalent of about half a million trees ending in landfills every week. We've been careless up to this point with the way we've treated the Earth and it's time to change; not just the way we do things but the way we think. Paper, plastic, glass, aluminum cans are examples of some products that are recycled in large quantities (Recycling guide, 2003).

When you think of recycling you should really think about the whole idea; reduce, reuse and recycle. Think about it; if you don't need it, don't get it. If you have to get it, get something that can be used again and if you get something that needs to be recycled by the professionals, put it in the recycle bin. Conservation is an important part of recycling issue. When you produce less garbage it helps in reducing the landfills and also helps in giving the land back to the nature (Recycling guide, 2003).

Recycling serve 2 purpose: First, it avoid landfills and helps in reducing air and water pollution and secondly, valuable material like aluminum cans and plastic and glass are reused in other forms and not wasted. Be mindful of what you do, pay attention to the items you buy and always check yourself to see if you really need it or if it comes in a package with less waste. We can all do our part and we will make a huge difference (Recycling guide, 2003).

1. Throw away all the garbage in your house that is of no use to you or you think you can't utilize it in some other way. If you don't have these boxes, you can easily purchase a suitable container for each recyclable product (e.g. paper, plastic, and glass), and then take these down to your local recycling center (Recycling guide, 2003).

2. Try to avoid the use of plastic bag and plastic paper as much as possible. They not only pollute the environment but also helps in filling landfills. Also, when you shop try to look out for the products that have least packaging. Every millions of dollars are spent only in packaging of these products which ultimately go to the garbage sites.

Interesting Recycling Facts

- It is said that every person creates around 4.7 pounds of waste every day.
- In the United States about 33.4% solid waste is recycled, 12.6% is burned in combustion facilities and about 54% is disposed of at a landfill site.
- Recycling an aluminum can preserves enough energy required to run a 100-watt bulb for 20 hours, a computer for 3 hours or a TV for 2 hours. Isn't it an interesting fact?
- About 125 recycled aluminum cans save up enough energy required to supply power to one home for 1 day.
- Recycled aluminum cans, are ready for reuse in just six weeks!

- An amazing fact about glass is that it never wears out and can be recycled forever. A glass bottle takes approximately 1 million years to decompose in a landfill site.
- A recycled glass bottle can save enough energy to run a computer for 25 minutes.
- Recycled glass containers can save about 9 gallons of fuel.
- Another amazing fact - recycled paper produces less air pollution than if it was made from raw materials.
- Each ton of recycled mixed paper can conserve energy equivalent to around 185 gallons of gasoline.

Recycling is an important step to undertake for preserving our planet by reducing environmental pollution and conserving energy. Hope this article has given you an insight about its benefits (Recycling guide, 2003).

2.5 The Economics of Recycling

In today's recycling infrastructure, recycling will only occur if there is an economic incentive to do so: if collection and processing costs are less than the value of the recycled end-product, recycling makes economic sense. For example, aluminum, steel, paper, and plastics #1 (PET) and #2 (HDPE) can be collected in high volumes, processed at relatively low cost, and then brought back to market for a profit. There are markets for these commodities, and they are often cheaper than virgin alternatives.

Yet for almost every other form of waste today, from snack bags and used toothbrushes to disposable coffee cups and plastic cutlery, collection and processing costs are greater than the value of the recycled end result. Without any economic incentive to recycle, we are forced to dispose of these waste streams as cheaply, and linearly, as possible — and is nothing cheaper or more linear than throwing garbage intoa landfill or burning it in an incinerator.

A variety of other factors can affect the costs of recycling, making it less profitable and less likely to occur. For example, single-stream recycling systems require more separation, which increases processing costs (i.e. less profit margins for recyclers). Contamination also poses a risk when consumers throw typically non-recyclable waste into these mixed streams. If these contaminants are accidentally processed at a Materials Recovery Facility, the quality of the recycled end-product can diminish significantly (i.e. it becomes less valuable on the market) (Recycling guide, 2003).

Recycling need not cost more than waste collection and disposal. In fact, recycling can make good economic as well as environmental sense, according to our recently published study (Recycling guide, 2003).

1. Recycling can cost less than disposal

2. Recycling and disposal system component costs

Solving Waste and Making Recycling Viable

To overcome these economic restrictions to recycling and reduce the volume of waste sent for linear disposal, there are a variety of actions that can be done at the individual, corporate and government levels.

For the individual consumer, this requires changing the way you purchase things and dispose of your waste. When possible, buy unpackaged fresh food and produce instead of prepackaged convenience foods, and forgo disposable products (e.g. plastic cutlery) in favor of durable products that last longer. Recycling properly is also key, which means identifying exactly what materials your municipality does and does not accept for recycling before throwing something into the curbside bin. If an item is not recyclable, upcycle it!

Individual action is not enough to curb the generation of waste and improve our recycling infrastructure. At the corporate level, product companies and brands can adopt better labeling systems like the How2Recycle Label, which informs consumers right on a product how to properly dispose of, compost or recycle each component of the item. Clearer labeling can keep potential contaminants out of the recycling stream, and can ensure widely recyclable materials will actually be recycled.

Finally, the government could improve our recycling infrastructure by forcibly making producers responsible for waste generated, and by making linear disposal less attractive. If producers were taxed for their product and packaging waste based on the actual costs of collection and processing (e.g. composting, reuse, recycling), manufacturers would have an explicit incentive to create products with more widely recyclable materials, less or no packaging, and to more closely engage with and educate consumers. A mandatory tax on landfilling and waste incineration could also make recycling and circular waste solutions more attractive (Alexis Manda Troschinetz, 2005).

Solutions like these could help us circumvent the common economic barriers preventing most of our waste from being recycled, and could make linear options like landfilling and incineration a thing of the past; but it will require collaboration on all fronts—between individuals, corporations, and government entities—to make these improvements come to fruition.

Factors Affecting Economics of Recycling (Alexis Manda Troschinetz, 2005)

1. The Price of Raw Materials

Perhaps the biggest economic barrier to recycling plastics is the relatively low cost of the raw materials required to make new materials. Feedstocks derived from natural gas and crude oil processing are relatively inexpensive, especially when compared with the fixed costs associated with recycling.

It’s likely that over the coming years this balance will begin to shift, both with likely rises in oil prices and lower cost approaches to recycling being developed (Alexis Manda Troschinetz, 2005).

2. Economies of Scale

A big challenge of recycling plastics can be that there are often only small quantities of certain types of plastic (per polymer type) available for recycling. This eliminates, or at least significantly reduces, the economic benefits arising from large-scale recycling. It therefore becomes a more involved, and expensive, process to recycle some of the less common polymers.

One potential method for overcoming this would be to centralize the processing of large volumes of plastic. While there is a clear logistical challenge here, with the right infrastructure the economies of scale could bring down the costs of recycling plastics.

This is something the EC have identified and as a starting point, they're looking to gather improved data and understanding of the different plastic flows across Europe (Alexis Manda Troschinetz, 2005).

3. Quality and Loss

It can be challenging to provide a reliable flow of recycled plastics, which would be required for the material to be easily integrated into a manufacturing supply chain.

The quality of the output material is one of the biggest barriers to being able to ensure a reliable supply. Additives to the plastic or the mixing of different types of polymer can significantly impact the quality and make-up of materials coming out of a recycling process. This makes recyclates a lot less appealing than brand new plastics in many applications (Alexis Manda Troschinetz, 2005). While there are serious economic challenges to recycling now, this is something that should begin to slowly move towards a new equilibrium. Both consumption and raw material costs look set to increase and there's a good chance that recycled materials will need to fill in the gaps (Alexis Manda Troschinetz, 2005).

Success Stories of Recycling

The Paper Recycling Success Story:

- The U.S. paper recovery rate rose to 65.8 percent in 2017.
- That's great news for the environment and for the paper industry. In fact, the annual paper recovery rate in the U.S. has nearly doubled since 1990, making it an American success story.
- AF&PA's sustainability initiative, Better Practices, Better Planet 2020, includes an industry goal to further increase paper recovery for recycling to exceed 70 percent by 2020.

Paper Recycling…

Extends the useful life of fiber

- Approximately 80 percent of all U.S. paper mills use some recovered fiber to make everything from paper-based packaging to tissue products to office paper and newspaper.

Keeps paper out of landfills

- More than twice as much paper is recycled than is sent to landfills.
- Every ton of paper recovered for recycling saves 3.3 cubic yards of landfill space.
- By weight, more paper is recovered for recycling from municipal solid waste streams than glass, plastic, steel and aluminum combined, according to EPA. Is widely accessible
- In 2014, 96 percent of Americans had access to community curbside and/or drop-off paper recycling programs.

Reduces GHG emissions

- AF&PA member companies' use of recovered fiber resulted in avoided greenhouse gas emissions of more than 18 million metric tons of CO_2 equivalents in 2016

Case Study

Startup- Recycle Impact -The world's first recycling-based crowd funding platform

Neeraj met Shankrith at another startup where they were colleagues. Shankrith expressed an interest in the idea, and the duo finally launched the startup in 2015. "In the first three months, Shankrith and I personally picked up recyclable trash from more than a 1,000 households in Powai. People laughed at us, but we learnt so much about a recycler's pain points. It was certainly a very humbling experience which we used to improve our company," adds Neeraj.

It has been an exceptional ride.

The startup, which has been bootstrapped since its inception in 2015, is aiming at organising the sector and empowering the local recyclers in the process. Explains Neeraj, "Our revenue model works like any other online crowdfunding companies - out-take fee. But what differentiates us is that we don't ask for cash. And secondly, we don't take any margin from the intended goal amount of the NGOs. Instead, we raise a little more than their required amount so that even they can complete their social impact cause easily. Thus, it's a win-win for everybody."

Every startup goes through highs and lows, and it has been the same with Recycle Impact. We have had many challenges and failures. People told me that this idea was difficult to implement and execute. We were asked, 'What's your U.S. equivalent?' I had no answer to this, since our model wasn't copied from anywhere. But we continued our journey, since we believed in ourselves. We are just happy that our work has a positive impact on society. Not everyone can get that kind of satisfaction from their jobs."

In November last year, Recycle Impact was one of four startups from India to be a part of a Make-in-India/ Startup India event in Berlin to showcase the top startups from each country. The event was held in association with the Bundesverband Deutsche Startups (German Startup Association). The company also won the United Nation's SEED Awards for Entrepreneurs in Sustainable Development in 2016, and were named as one of the top 10 eco-inclusive waste management firms globally. This award is usually given to organisations working on sustainable development and locally-driven entrepreneurs around the globe who integrate social and environmental benefits into their business model.

The impact has been phenomenal:

Recycle Impact is working for the benefit of people at the grassroots level. According to Neeraj, there are plenty of hardworking but cash-strapped NGOs doing good work, but we don't hear about them, because they don't have huge marketing budgets. "Through our portal, organisations can raise funds easily and continue to do their work and bring about social impact. In the entire recycling ecosystem in India, the local-recycler is the most hardworking yet the most neglected element. We have included them in our system, which gives them more pick-ups and inventories to increase their daily income. If people are motivated to recycle more, we can bring about massive change," he adds.

Case Study

From trash to treasure: This Mumbai startup recycles waste and transforms lives for the better

Ever wondered what happens to the trash that is picked up from your house? Does it make its way to a landfill,, or do parts of it get dumped into some water body?

The current motto of *Swachh Bharat* notwithstanding, India remains one of the top ten waste-generating countries in the world. With a daily output of over 70k million tonnes of all kinds of garbage, India is also one of the lowest-ranking countries in terms of recycling.

Waste management remains one of the major issues that India is facing. That is exactly why Recycle Impact - the world's first recycling based crowdfunding platform which is working to combat this problem- won the Tissot Signature Innovators Club Award for June 2017.

Shankrith Narayan & Neeraj Shetty with the happy faces from Child Reach

All it takes is an idea

Founded by Neeraj Shetty and Shankrith Narayan, the Mumbai-based startup ensures that waste is properly recycled, and the funds generated by recycling scrap are utilised for a meaningful social impact cause. Neeraj says, "The idea struck me when I was working for a college campaign. We collected various types of recyclable scrap in college like papers, books, plastics, metals, newspapers, and cartons for three whole days, and got Rs 5,340 from all the waste we recycled. This money was used to buy books, goodies, bats and footballs for a bunch of underprivileged kids who lived in an ashram attached to our college."

Case study- Start up- Recycle Impact -The world's first recycling based crowd funding platform
The startup has now developed an Android app for local recyclers, through which a customer can recycle scrap material (like paper, cartons, plastic, metals, glass and electronics), get to know the exact amount generated by recycling the scrap, and donate the same to crowdfund a social cause of their choice. Also linked with the mobile app is a live crowdfunding link on the website, which ensures that the entire process is very transparent.

The next step: According to Neeraj, each house generates only around Rs.150-200 worth of recyclable waste every month. Their main customers are households and building complexes, though they also operate in schools and colleges. In future, they're looking to add corporate, offices, hotels and industrial estates onto their list. Neeraj notes, "In the last academic year, we were in seven schools and taught more than 1,000 students about waste management, recycling and involved them in our impact campaigns too. This academic year, we have tied up with more than 40 schools, and hope to reach more than 10,000 students."

Analytical Hierarchy Process (AHP)

Solid waste management is a major challenge for our cities. Therefore, a better strategy and planning is important to improve the efficiency and effectiveness of solid waste management. A multicriteria decision making technique, Analytical Hierarchy Process (AHP), which utilizes a multi-level hierarchical structure consists of objective, criteria, subcriteria, and alternatives is applied in selection of an appropriate solid waste treatment technology (MohdArmi Abu Smah, 2010).

The Analytical Hierarchy Process (AHP)

Basically, a tool that permits explicit presentation of evaluation criteria and possibly improves selection of technology for solid waste management plan is the Analytical Hierarchy Process (AHP). Multicriteria decision analysis (MCDA) models, such as the AHP, are used to consider waste management options. The AHP (Saaty, 1980, 1990) is known multi attribute weighting method for decision support (Madu, 1994). AHP is a decision approach designed to aid in the solution of complex multiple criteria problems in a number of application domains (Saaty, 2000). Keeney (1982) has divided decision analysis into four phases (the previous three plus one addition aspect: -

(1) structure the decision problem,

(2) assess possible impact of each alternative,

(3) determine preference of decision – makers, and

(4) evaluate and also compare decision alternative.

Thus, Analytical Hierarchy Process (AHP) is suitable to be applied in solid waste management because it can help in making decision in selecting solid waste treatment technology more effectively.

The knowledge acquisitions process for structuring the decision are obtained from many sources such as availability of human expert, literature and secondary information about the waste management(MohdArmi Abu Smah, 2010).

Analysis from data in Table 2.1 shows all of the selected subcriteria are to be filled in the General Hierarchy Structure Model (GHSM).

Table 2.1 Data Analysis for Selection of Criteria in Solid Waste Management

Table 2: Data Analysis for Selection of Criteria in Solid Waste Management

Criteria Political Support	*Total*	*Percentage (%)*
Location	5.16	17.2
Public Acceptance	4.6	15.3
Criteria Technical Expertise	*Total*	*Percentage (%)*
Feasibility	5.3	17.6
Experience	5.04	16.8
Criteria Environmental Impact	*Total*	*Percentage (%)*
Water Pollution	3.78	12.6
Public Health	3.59	11.9
Criteria Market Potential	*Total*	*Percentage (%)*
Estimates Cost	3.83	12.7
Financial Management	3.76	12.5
Criteria Community Involvement	*Total*	*Percentage (%)*
Cooperation	7.57	25.2
Interest Message	6.98	23.2
Criteria Cost	*Total*	*Percentage (%)*
Operation Cost	8.87	29.5
Capital Cost	8.72	29.0

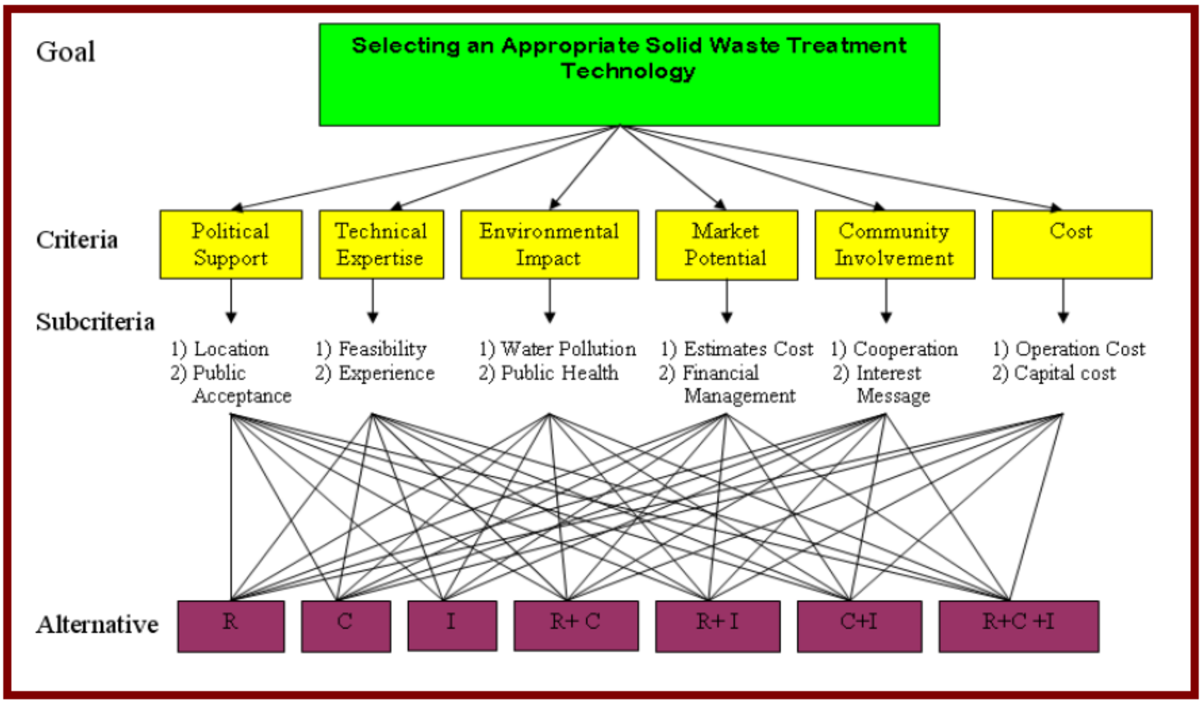


Figure 2.3: General Hierarchy Structure Model (Sources: MohdArmi Abu Smah , 2010)

Where:

R: Recycling

C: Composting

I: Incineration

R+C: Combination of Recycling + Composting

R+I: Combination of Recycling + Incineration

C+I: Combination of Composting + Incineration

R+C+I: Combination of Recycling + Composting + Incineration

Application of Pairwise Comparison Matrix (PCM)

To apply pairwise comparison method, at first step we need to form a pairwise comparison matrix for all the criteria. The degree of preference of the decision makers in the choice for each pairwise are quantified based on a ratio scale of (1/9, 9) (MohdArmi Abu Smah, 2010). The scale was originally because the comparison will be made within a limited range where perception is sensitive enough to make a distinction. The interpretation of this scale is provided in Table 2.2.

Table 2.2 Table Scale of preference

Verbal judgment of importance	*Numerical rating*
Equal importance	1
Equal to moderate importance	2
Moderate importance	3
Moderate to strong importance	4
Strong importance	5
Strong to very strong importance	6
Very strong importance	7
Very strong to extremely strong importance	8
Extreme importance	9

(Adapted from Saaty, 2000)

To find out the weight, at first we determined the largest eigen value λmaks. Then the weight wi's are determined by solving the following system of linear simultaneous equation:

$$W_i = 1/\lambda_{maks} \sum_{j=1} a_{ij} w_j,\ i = 1, 2, \ldots, n$$

for uniqueness, we normalize the set of weight such that

$$\sum_{i=1}^{n} w_i = 1$$

The consistency index is defined by

$$C_i = \lambda_{maks} - n / n-1$$

As usual, CR = CI / RI

= < 0.1 = Acceptable

= > 0.1 = Not Acceptable

The overall results for the solid waste treatment technology at Sepang Municipal Council (SMC), Malaysia (MohdArmi Abu Smah, 2010):

This analysis is based on data obtained from the user namely policy maker at the Sepang Municipal Council (SMC) who hold the position as a director under the Department of Environmental Health which responsible in supervising solid waste management throughout Sepang District. Basically, the overall result from Table 2.3 shows that the combined recycling and composting technology is ranked first for Sepang municipal solid waste treatment technology with weight of 0.13. Others technologies such Incineration is weighted 0.12, combination recycling and Incineration is weighted 0.10, combination technology composting and incineration is weighted 0.09, recycling is weighted 0.08, composting is weighted 0.07 technologies with last ranking is combination recycling, composting and incineration with weight of 0.07. Thus, it is expected that the finding from this study will be used as decision support system and guideline in term of selecting an appropriate solid waste treatment technology for Sepang Municipal Council and reducing the problems regarding to solid waste management in Sepang Selangor (MohdArmi Abu Smah, 2010).

Table 2.3 The Ranking of Solid Waste Treatment Technology

Solid Waste Treatment Technology	*Weight*	*Ranking*
Recycling + Composting	0.13	**1**
Incineration	0.12	**2**
Recycling + Incineration	0.10	**3**
Composting + Incineration	0.09	**4**
Recycling	0.08	**5**
Composting	0.07	**6**
Recycling + Composting + Incineration	0.07	**7**

Development of Hierarchy Structure Model

Knowledge on selection of solid waste treatment technology which acquired from multiple sources were structured into hierarchy which shown in Figure 1. The AHP technique is performed with the goal to select an appropriate solid waste treatment technology that will be able to produce the best and optimum outcome in long term. There are 6 important criteria resulted from in the hierarchy structure namely, political support, technical expertise, environmental impact, market potential, community involvement and cost. Therefore, location, public acceptance, feasibility, experience, water pollution, public health, estimates cost, financial management, cooperation, interest message, operation cost and capital cost (Wilson, 1981), were selected as the subcriteria to support the main criteria that had been selected before. The components of Recycling, Composting and Incineration were selected as single technology alternative. Furthermore combination of Recycling + Composting, combination of Recycling + Incineration, combination of Composting + Incineration and also combination of Recycling + Composting + Incineration was selected as the combination technology alternative in the General Hierarchy Model Structure (GHSM) (MohdArmi Abu Smah, 2010).

Reverse Logistics

Reverse logistics stands for all operations related to the reuse of products and materials. It is "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal (Mateusz Jakubiak, 2015). More precisely, reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics." The reverse logistics process includes the management and the sale of surplus as well as returned equipment and machines from the hardware leasing business. Normally, logistics deal with events that bring the product towards the customer. In the case of reverse logistics, the resource goes at least one step back in the supply chain. For instance, goods move from the customer to the distributor or to the manufacturer (Mateusz Jakubiak, 2015).

When a manufacturer's product normally moves through the supply chain network, it is to reach the distributor or customer. Any process or management after the sale of the product involves reverse logistics. If the product is defective, the customer would return the product. The manufacturing firm would then have to organise shipping of the defective product, testing the product, dismantling, repairing, recycling or disposing the product. The product would travel in reverse through the supply chain network in order to retain any use from the defective product. The logistics for such matters is reverse logistics (Mateusz Jakubiak, 2015).

Reverse logistics is quite different from the traditional logistics, or forward logistics, activities. The below Fig. 2.4 is a traditional logistics flow:

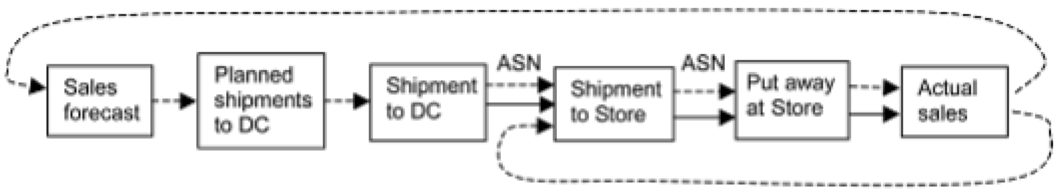


Fig. 2.4 Traditional logistics (Source: Mohammed Alnuwairan, 2018)

Sales forecast is used to project sale requirement, when certain amount product is required, they will be shipped to the DC (distribution center) and then shipped to the retail stores from DC. At every single level of the supply chain, ASNs (Advanced Shipping Notices) will be assisting the useful information as the products flow (Mateusz Jakubiak, 2015).

Reverse logistics flow, however, is a different story. Shippers generally do not initiate reverse logistics activity as a result of planning and decision making on the part of the firm, but in response to actions by consumers or downstream channel members. Here is the Fig. 2.5 outlining what is reverse logistics flow:

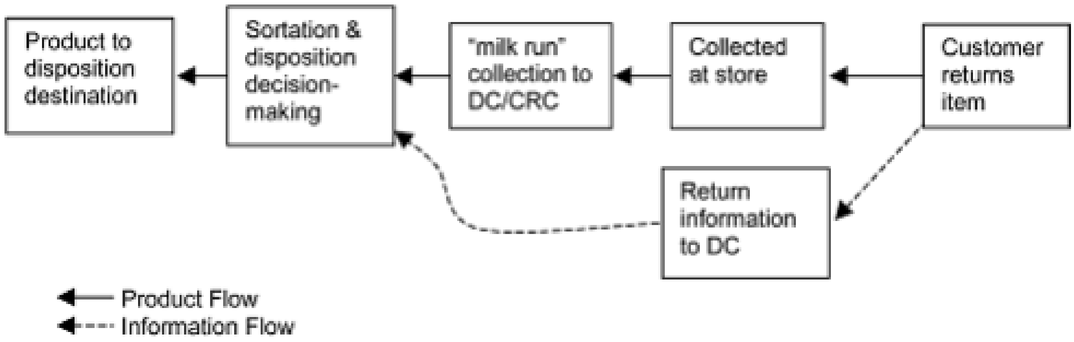


Fig. 2.5 Reverse logistics (Source: Mohammed Alnuwairan, 2018)

When a return occurs, the returned product will be collected (in many different ways) and sent to thedistribution center. At the same time the relevant information about the return item description, condition at return, customer information etc., will be transferred to the return processing center, but unfortunately, given the current state of the reverse logistics status quo, this information capture process rarely occurs, or occurs with less accuracy(Mateusz Jakubiak, 2015).

Reverse logistics is a process whereby companies can become more environmentally efficient through recycling, reusing, and reducing the amount of materials used. A more holistic view of reverse logistics includes reduction of materials in the forward system in such a way that fewer materials flow back, reuse of materials is possible, and recycling is facilitated (Mohammed Alnuwairan, 2018).

The measures aimed at reducing waste begin in the product design phase and incorporate the entire product life cycle, including transportation and final disposal. This will allow minimizing the waste downstream and allowing the product to go backward in the chain for possible re-manufacturer, reuse, recycling, or resell for secondary market (Mohammed Alnuwairan, 2018).

Reverse Logistics vs Waste Management

Reverse logistics differs from waste management in that it focuses on the addition of value to a product to be recovered. On the other hand, waste management involves mainly the collection and treatment of the waste products that have got no new use (Fig. 2.6).

A reverse supply chain is the network of activities involved in the reuse, recycling, and final disposal of products and their associated components and materials. The public is only concerned with the aftermath environmental impacts of the products at the end-of-use life.

Life Cycle Assessment (LCA) is an important tool in reverse logistics and involves assessing alternative materials and component concepts from the start of the development process and throughout the entire product life cycle, from the retrieval of raw materials through the utilization phase to recovery.

Worldwide Scenario

Waste management legislation in Europe is strong where firms are directed to address recovery and disposal of end-of-life products in an environmentally sound manner. As far as United States is concerned, economic factors focused on resource recovery value have been the main motivating factor. On the other hand, reverse logistics in emerging economies is in early stages and depends heavily on third-party provider due to shortage of legislation, awareness, and infrastructure. Professional collection, sortingand transportation of end-of-life products are much needed in emerging markets such as Middle East (Mohammed Alnuwairan, 2018).

In the developing world, reverse logistics work is characterized with low value addition due to the low reprocessing involved for example from recycled electronics, paper, automobiles, scrap, plastics and food waste. Unfortunately reverse logistics has not received the desired attention in developing countries and is generally carried out by the unorganized sector for recyclables like paper, plastics and metal (Mohammed Alnuwairan, 2018).

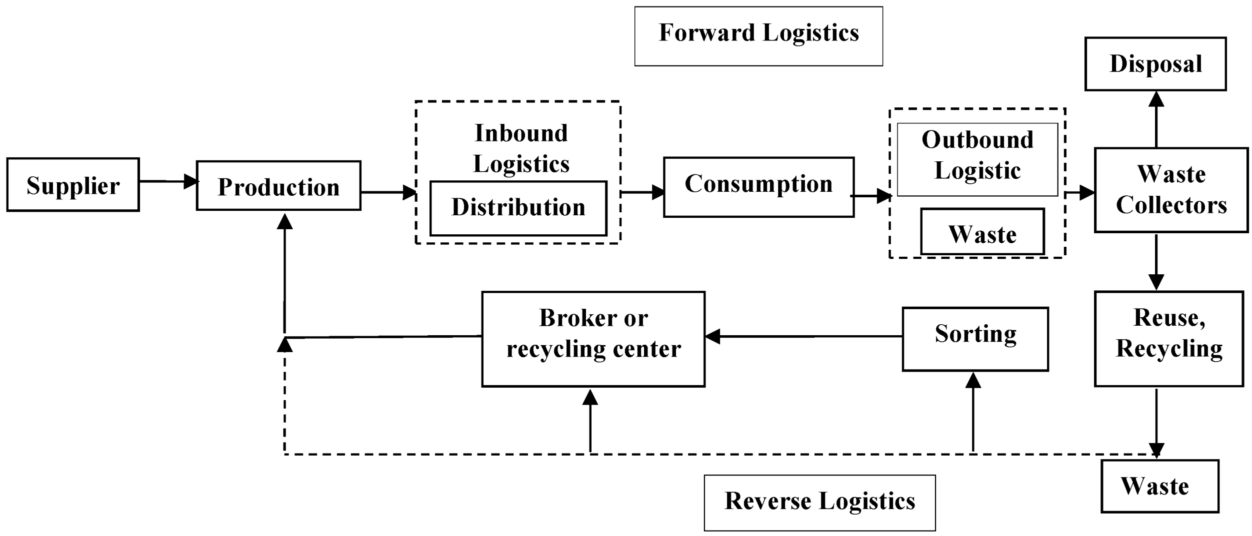


Fig. 2.6 How reverse logistics can aid in sustainable waste management (Source: Mohammed, 2018)

2.6 Best Practices for Reverse Logistics Management

A proper business practice reverse logistics (Fig. 2.7) will help any organization to keep track of customer's opinions and needs for a long time. By considering contemporary business practices and legislative norms and keeping reverse logistics process in mind an effort has been made in the paper to suggest general bestpractices for efficient management of reverse logistics (Mateusz Jakubiak, 2015).

1. First and foremost thing is to set up a Reverse Logistics team which is accountable for all the reverse logistics activities. This team would consist of top management and experienced people who will be held responsible for all reverse logistics activities of the organization. It should be given all rights to take decisions at any point of time and

2. Set up proper Management Information Systems which will track all the activities end to end of reverse logistics process. Information of returns should flow across various departments more specifically in the areas of design and R&D. Also the customers should be able to keep track of their products at various stages of the process.
3. Build a customer support team which will track only returns and which will help customers to ease their returns. Customers thereby understand the way by which their product is flowing through reverse supply chain.
4. Frame policies and procedures regarding returns at each of product life cycle till disposition of the products which will satisfy all the legislative norms of the state(Joseph Huscroft, 2014).
5. If setting up a separate logistics is not feasible for the organization, it can have the option of outsourcing its reverse logistics functions to third parties. Since proper collaboration with third party logistics will reduce not only the cost but also provide enough time to improve its core competent areas.

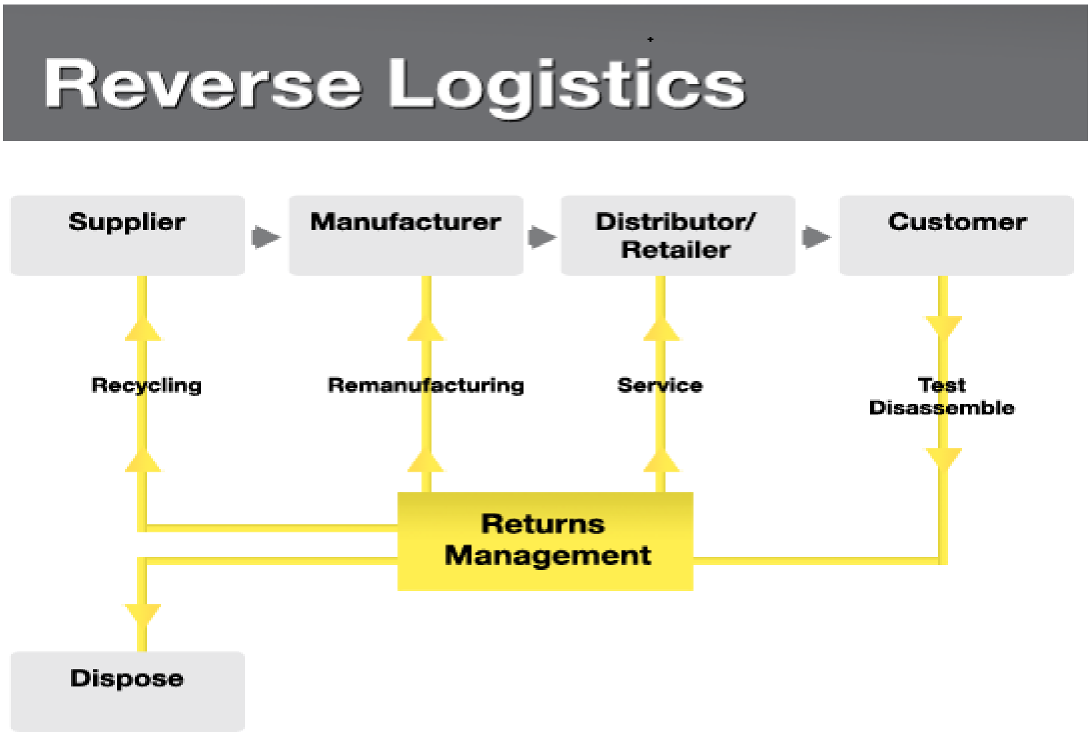


Fig. 2.7 Reverse logistic (Source: Mohammed Alnuwairan, 2018)

With the advent of sophisticated management systems, organizations have discovered the logic of prioritizing a reverse logistics system, which has led to the development of advanced technology that supports the process. Much of this development derived from the electronics sector, in which product lifecycles are significantly shorter, global service networks are increasingly intricate, sustainability processes are mandated and consumer customization is becoming the norm(Joseph Huscroft, 2014).

However, for many organizations, the returns management process has remained a cost center with low visibility that contains products to be restocked, repaired, recycled, repackaged or disposed of appropriately. Conventional logistics service providers had very few alternatives for reversing the channel; however, as the technology has progressed, companies using a robust, proficient reverse logistics system have benefited from:

1. Reduced administrative, transportation and aftermarket support costs.
2. Increased velocity.
3. Increased service market share.
4. Higher achievement of sustainability goals.
5. Greater customer service and higher retention levels.
6. Recovery of capital investments in assets

Importance of Metrics in Reverse Logistics Management

To monitor progress against its reverse logistics management plan, a company needs metrics that measure the financial impact of returns on the firm and on other members of the supply chain. As part of this process, the company should develop procedures for analyzing return rates and tracing the returns back to the root causes. Measures such as amount of product to be reclaimed and resold as is, or percentage of material recycled, are examples of such metrics (Joseph Huscroft, 2014).

These metrics came from this amazing article on reverse logistics management which I encourage you to read fully, in Logistics Management:

In analyzing your company's reverse logistics system performance, consider tracking these metrics:

- Disposition cycle time: Cycle times can be an important measure of reverse logistics. The more standardized and streamlined the processes are, the shorter the cycle time should be.
- Amount of product reclaimed and resold: What percentage of product that moves to the reverse statistics system is reclaimed and resold? How much value is recaptured?
- Percentage of material recycled: This metric tracks the percentage of product in the reverse logistics stream that is recycled in an appropriate manner.
- Waste: How much product and other materials are moved to landfills, incinerated, or disposed of as waste? The objective is to minimize product in the waste streams.
- Percentage of cost recovered: Is the firm maximizing the profitability of product that did not sell well or has been returned by consumers?
- Per item handling cost: A cost-per-touch type of metric can be readily computed by dividing total facility costs per month by the number of items processed. This is also a valuable way to compare the efficiencies of different facilities (Joseph Huscroft, 2014).
- Distance traveled: Tracking average distance traveled per item is not nearly as simple as determining per-item-handling cost. Generally speaking, the fewer miles that can be put on an item in the reverse logistics network, the better.

- Energy used in handling returns: This metric is used in sustainability programs. It measure how much energy (diesel fuel, electricity, etc.) is used in the reverse logistics process.

- Total Cost of Ownership: What is the total cost of ownership related to originally acquiring the product, reselling it, bringing it back as a return, and moving it through a secondary market or placing it in a landfill?

Reverse logistics system practices vary based on industry and channel position. Industries where returns are a larger portion of operational cost tend to have better reverse logistics management system and processes in place. In the book industry, where great change in the industry structure has occurred in the last few years, returns are a major determinant of profitability. In the computer industry where life cycles are nearly as short as grocery life cycles, the speedy handling and disposition of returns is now recognized as a critical strategic variable (Joseph Huscroft, 2014).

Successful retailers understand that managing reverse logistics effectively will have a positive impact on their bottom line. Industries that have not had to spend much time and energy addressing return issues are now trying to make major improvements. Now, more than ever, reverse logistics is seen as being important(Joseph Huscroft, 2014).

5 Process Improvements along the Way

In attempting to improve reverse logistics system processes, a firm can move along several fronts. Suggested improvements:

- Streamline turn-in procedures
- Route items with an eye to what happens to them next
- Integrate the forward and reverse pipelines
- Explore the potential of commercial software applications or techniques for improving reverse flow management (such as the new Cerasis Reverse Logistics product within our transportation management system.)
- Align financial incentives with improvements

Key Reverse Logistics Management Elements:

- Gate keeping
- Compacting Disposition Cycle Time
- Reverse Logistics Information Systems
- Central Return Centers
- Zero Returns
- Remanufacture and Refurbishment
- Asset Recovery
- Negotiation
- Financial Management
- Outsourcing

Advantages of Partnering with 3PL for a Reverse Logistics System

Organizations that partner with a sophisticated third-party logistics service provider (3PL) benefit from greater controls over the entire supply chain resulting in improved inventory management, increased visibility, reduced costs and enhanced risk management. Specifically, the benefits of utilizing the expertise of a 3PL for a reverse logistics system produces greater controls over inspecting, recovering, testing and disposing of returned products(Joseph Huscroft, 2014).

The nature of reverse logistics management includes higher uncertainty and threats than forward logistics. Companies find it difficult to predict which products may have higher than normal fail or return rates. In addition, products may come back in unrecoverable conditions. The complexity of the reverse system grows as manufacturers may have specific procedures for literally thousands of unique SKUs.

It might be the most ignored aspect of warehouse operations today. But the need for efficient reverse logistics management cannot be brushed aside anymore. The return, processing, repair and replacement of products have a huge impact on customer service. And the nerve center of any such operation is the warehouse (Joseph Huscroft, 2014).

Summary

Communication technologies such as Radio Frequency Identification (RFID), Global Positioning System (GPS) and General Packet Radio System (GPRS) are now integrated with Geographic Information Systems (GIS) for monitoring the solid waste management system. These can be suitably adopted by cities to improve the efficiency of service.

Vehicle routing and scheduling (VRS) is a major and established area of operations research, Procedures have been developed for determining the routes andor schedules for freight or passenger vehicles so that the individual or total indices (travel time, travel cost, travel distance, etc.) are optimised, while various requirements (constraints) are met. Improved performance of distribution systems has resulted from the application of such procedures.

Various methods have been explored as augmentations to GPS signals to derive continuous precise positioning on GIS-based maps, which is vital for fleet management applications.

Recycling is important in today's world if we want to leave this planet for our future generations.

A multicriteria decision making technique, Analytical Hierarchy Process (AHP), which utilizes a multi-level hierarchical structure consists of objective, criteria, subcriteria, and alternatives is applied in selection of an appropriate solid waste treatment technology.

Reverse logistics is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.

To Do Activities

1. Discuss in class applications of GPS and GIS in waste management

2. View a video on applications of GPS and GIS in waste management

3. Read a case study on success story of waste recycling

4. Read a case study of best practices in waste management

5. Discuss any one start up in waste management

6. Discuss analytical hierarchy process in waste management

7. Predict the effect of incentives for recycling on the supply and demand for a good, and on equilibrium quantities.

8. Develop strategies for reducing the amount of waste disposal at landfills

Self-Assessment test

1. Discuss various integrated technologies used for monitoring solid waste management.
2. Explain Dynamic Vehicle Routine and scheduling.
3. Discuss GPS augmentation
4. Give a thought on importance of recycling
5. Explain economics of recycling and factors affecting recycling.
6. Explain how Analytical Hierarchy Process can be used in solid waste management.

Chapter 3- Storage and Processing

Introduction

Waste processing and treatment includes a lot of different processes. Aside from the organizational, structural and technical measures of waste treatment, the following should also be considered: Controlled landfilling, Thermal treatment, Biological treatment, Chemical-physical conversion, Mechanical treatment and Recycling

Objectives

- To know the components of solid waste that can be recycled
- To understand the simple methods of composting and its benefits
- To understand process of recycling

Structure

3.1 Management of Waste Collection

3.2 Source segregation management

3.3 Preventive Maintenance

3.4 Composting

3.5 General Process of Recycling

3.6 Precautions for Recycling

3.1 Management of Waste Collection

The waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which classifies waste management strategies according to their desirability in terms of waste minimisation. The waste hierarchy is the cornerstone of most waste minimisation strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of end waste; see: resource recovery. The waste hierarchy is represented as a pyramid because the basic premise is that policies should promote measures to prevent the generation of waste. The next step or preferred action is to seek alternative uses for the waste that has been generated i.e. by re-use. The next is recycling which includes composting. Following this step is material recovery and waste-to-energy. The final action is disposal, in landfills or through incineration without energy recovery. This last step is the final resort for waste which has not been prevented, diverted or recovered. The waste hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management. The hierarchy represents the latter parts of the life-cycle for each product (SivakumaranSivaramanan, 2015).

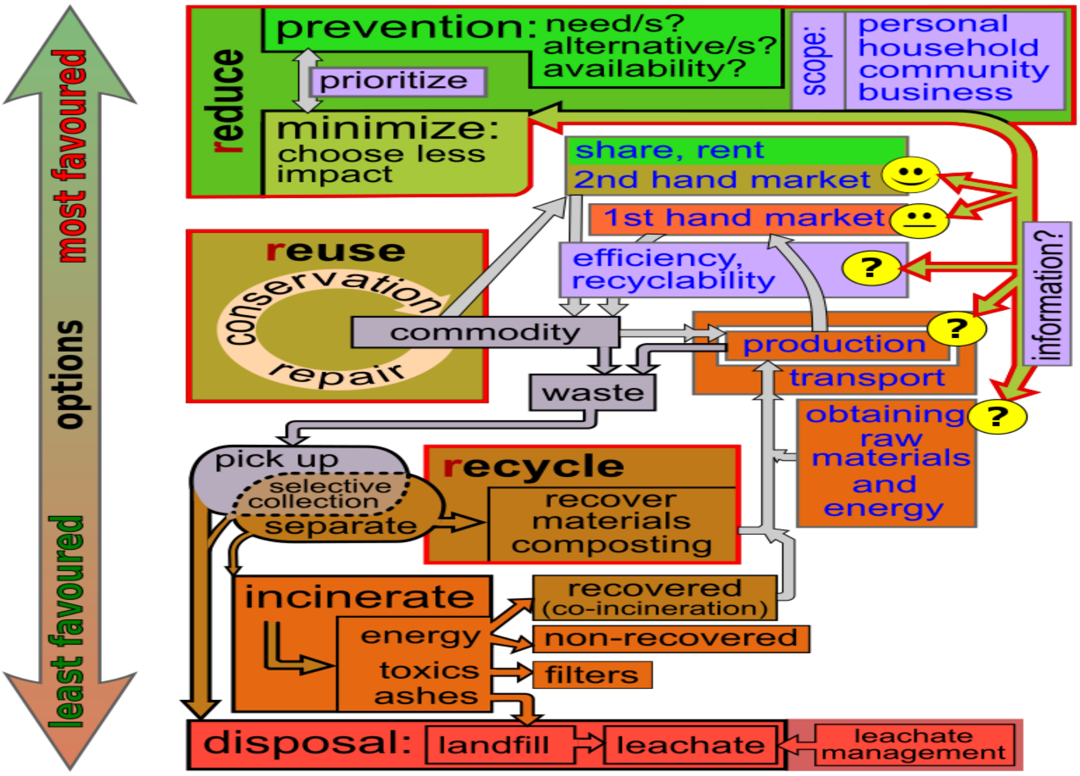


Fig. 3.1 Principles of Waste Management (Source: Sivakumaran Sivaramanan, 2015)

Life-cycle of a Product

The life-cycle begins with design, then proceeds through manufacture, distribution, and primary use and then follows through the waste hierarchy's stages of reduce, reuse and recycle. Each stage in the life-cycle offers opportunities for policy intervention, to rethink the need for the product, to redesign to minimize waste potential, to extend its use. Product life-cycle analysis is a way to optimize the use of the world's limited resources by avoiding the unnecessary generation of waste (SivakumaranSivaramanan, 2015).

Resource Efficiency

Resource efficiency reflects the understanding that global economic growth and development can not be sustained at current production and consumption patterns. Globally, humanity extracts more resources to produce goods than the planet can replenish. Resource efficiency is the reduction of the environmental impact from the production and consumption of these goods, from final raw material extraction to last use and disposal (SivakumaranSivaramanan, 2015).

Polluter-pays Principle

The polluter-pays principle mandates that the polluting party pays for the impact on the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the unrecoverable material (Lees, 2015).

The 'polluter pays' principle is the commonly accepted practice that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment. For instance, a factory that produces a potentially poisonous substance as a by-product of its activities is usually held responsible for its safe disposal. The polluter pays principle is part of a set of broader principles to guide sustainable development worldwide (formally known as the 1992 Rio Declaration (Lees, 2015).

3.2 Source Segregation Management

Fig. 3.2 Classification of waste (Source: MufeedSharholy, 2008)

In simple terms, waste segregation is the separation of wet waste and dry waste. The generation of waste is unavoidable, and the materials carried in this waste impacts human and environmental health. Naturally, waste management is something that must be carried out, and one way to do this meticulous segregation of wet and dry waste, so that dry waste can be recycled and wet waste can be composted (MufeedSharholy, 2008).

When we segregate waste, there is reduction of waste that reaches landfills and occupies space. Air and water pollution rates are considerably reduced, and makes it easier to apply different processes – composting, recycling and incineration can be applied to different kinds of waste. Waste management starts at the household level, and is not that difficult to achieve. Even a few minor changes can go a long way. Firstly, have two garbage disposal bins at home, one for dry waste and one for wet waste. Items like aluminum foils, tetra packs, glass, paper, plastics, metals, etc. fall under the dry waste category, whereas kitchen waste such as stale food, fruits and vegetables come under wet waste (MufeedSharholy, 2008).

It is important to make sure that wet waste is thrown out of the house on a daily basis. Dry waste can be discarded twice or thrice a week. Ensure that plastic containers thrown in the dry waste bin are void of any food residue. Besides taking measures at an individual level, try involving like-minded people and form a community solely dedicated to waste management in your apartment complex. Introduce two separate disposal drums on your complex ground, and explain to people the importance of this segregation. The process of waste segregation should be thoroughly explained to family and neighbours in your apartment building. Create awareness amongst the staff in the apartment building to help make the process easier.

The importance of waste segregation in the world cannot be understated. Waste Segregation is the first step in a compliant waste management plan that will help the save the environment and improve the quality of the atmosphere we live in. It really does matter which bin you put the garbage into.

If done in a proper manner, waste management not only eliminates the surrounding waste, but also will reduce the intensity of the greenhouse gases like methane, carbon monoxide which gets emitted from the wastes accumulated. The depth of the existing landfills will be also curbed, thereby cutting down whatever is toxic to the environment. The number of fossil fuels will also get reduced in this manner, leading to a cleaner and a greener environment (MufeedSharholy, 2008).

Collection

The work of a waste management logistician begins with collection. This process needs micro-planning to ensure:

- Maximum waste is collected with minimum transportation and minimum labour.
- No backlogs are created in the collection.
- There is a back-up plan if there is a breakdown of the collection plan.

For ensuring that waste is collected the customer- business or home must register ~~itself~~ and pay a monthly fee for waste collection. They must agree to follow the rules set by the waste collector, such as segregation, use of colour coded-bins, collection time and dates, method of keeping the waste at the curb side, avoiding putting certain kinds of waste in the garbage, etc. The example of the last category could be hazardous substances like sharps, explodable substances like aerosol cans, toxic material or certain recyclables like cardboard which are collected separately (MufeedSharholy, 2008).

Workers collect waste usually in pairs, each pair collecting from 200 households per day. These are brought to community bins using handcarts, cycle carts etc. Road sweepings, waste from businesses etc are also collected and added to the community bins.

Collection is sometimes centralized, wherein bins are kept at a central location and the public bring their segregated waste to put in these bins. Such an arrangement also calls for varying degrees of environment awareness and consciousness among the citizens. On the whole, this trend of delivering waste to the common bin is on a decline in India. Countries like Sweden have a 7- bin system where people deposit different kinds of recyclable and dry waste only. They must compost all organic waste at home. It is important that segregation should be done with minimum mistakes to make the task of the waste managing agency easy when they deal with bulk quantities of waste (MufeedSharholy, 2008).

Fig. 3.3 Segregation of waste (Source: MufeedSharholy, 2008)

Certain waste management companies have a customer care helpline, through which their waste collection needs can be scheduled or prioritized under unusual circumstances. Pre-registration ensures proper planning for manpower and transportation needs by the waste management company.

Under the Swachh Bharat Mission (urban) every effort is being made to practice a 2-bin waste segregation and door-to-door waste collection. Organized women groups (collectives) are being engaged to do door-to-door waste collection. The municipality provides them with the means of transportation and other necessary safety equipments. Several municipal corporations have tried to outsource waste collection to private agencies in the past, but were disappointed. It has been repeatedly proven in Indian cities that the functioning of a successful garbage management programme requires people’s participation as well as the involvement of organized collective bodies (e.g. waste-pickers association or self-help groups) along with municipal involvement.

Manifest

A manifest is a document which the recycler or the waste collector needs to create and the transporter needs to carry. A copy is sent to the recipient. A manifest document is imperative for hazardous waste. The EPA makes it compulsory to fill out a Uniform Hazardous Waste Manifest - a form required by the Department of Transportation for all generators who transport, or offer for transport, hazardous waste for off-site treatment, recycling, storage or disposal. It explains exactly what is present in the load of garbage. If a case of emergency arises during transit, the manifest gives an idea of how to manage the waste.

Manifest is also important for scrap trade, where it reveals the content of each container being shipped from one country to another. A manifest is preserved for at least 3 years. As garbage follows the path from cradle to grave, it is important to follow its journey till the end. Certain segments of waste transformed into useful material. This too can be tracked through the manifest document. A picture of a manifest form is pasted as an example (MufeedSharholy, 2008).

Transportation

The agency transporting waste from the collection site to the processing unit must have a licence to do so. This is the responsibility of the municipality. Sometimes they may use civil hired transport. Waste management logistics is of utmost importance for further processing which requires manpower, transportation, equipment, schedules, coordination and supervision. The government usually has compliance requirements for waste management companies and their employees that should be adhered to for safety purposes.

Planning the route for waste collection vehicles is an important step. A number of transfer stations are placed in urban areas. In most locations, there is only one site for final treatment and disposal, which is usually situated at the edge of the town. Route mapping consists of three stages:

I. Identifying the pickup points and the likely amounts of waste to be collected from each point.

II. Grouping pickup points to form 'collection rounds' that can be served by a single collection vehicle.

III. Planning the route of each collection round taking account of the distance travelled, traffic levels and safety to the public and the waste collectors.

Sometimes GPS is used to track the progress of the waste (MufeedSharholy, 2008).

Sorting at the Secondary Level (in transfer stations)

Segregation can be of several categories. The Japanese village of Kamikatsu has turned segregation into an exacting art, with 34 categories, that too at a primary level, at home. But without Japanese discipline, this model cannot be replicated across the world (MufeedSharholy, 2008).

In India, most of the segregation is done by the informal sector of kabadi/ bhangarwalas (waste collectors). This secondary level segregation takes place mostly at the waste dumps after collection and transport. Once the waste reaches the transfer station, it is to be decided how best to deal with it. It makes sense to extract as much usable material out of it to make the business profitable and prevent resources from reaching the dump yards.

Many of the items can be recycled easily. These include aluminium cans, glass, steel, paper and certain plastics**.** The film on 'Tour of Ontario's Recycling Centre' clearly depicts segregation within the recycling centre. A similar format of segregation is practiced in Indore, Pune.

(Watch Film on Sarthak Indore: Plastic Waste Management project -Movie made by UNDP Duration 2min. https://www.youtube.com/watch?v=7NwpQUw9gIs)

Care should be taken for proper segregation of dry waste into categories of metals, glass, paper, cardboard and plastics. Each segregated waste stream is sent separately for recycling. There are codes for segregation, which need to be understood and followed. Some of these are explained in the next chapter.

Other things that can be recycled include:

- Batteries: rechargeable batteries contain heavy metals, nickel, cadmium and zinc. Hence they MUST be recycled instead of throwing away.
- CDs/DVDs/Video Game Disks: These can be refurbished and resold.
- Eye Glasses: The lenses and frames of eyeglasses can be remade.
- Foam Packing
- Razors/Toothbrushes: If the plastic is recyclable, you can recycle these common toiletries.
- e-waste: electronic goods like cell phones, computers and old appliances.

There is also much confusion about categorizing certain waste. For instance, cardboards are often coated. They may be poly-coated, which makes them recyclable, but not compostable. Meanwhile wax coated items can be composted, but never recycled, because the wax comes off during the pulping process and makes the freshly recycled paper unfit for printing.

Composite materials are hard to recycle as they are made of many plastics. TerraCycle, a USA based innovative recycling company works on recycling hard-to-recycle waste including latex gloves, pens and cigarette butts to name a few. They have a setup with Colgate to recycle toothbrushes, floss boxes and toothpaste tubes. Most recyclers do not accept such material. TerraCycle is not yet present in India. It is a good business opportunity to venture into recycling of hard-to-recycle waste.

Once the waste is segregated, it is baled and sold off to the respective recycling centre. This is a major source of income for the waste management facility.

Reducing Waste Volume

After extracting all the recyclable, reusable, compostable materials, we need to find ways to reduce the bulk of the remaining matter. There is an option of burning the waste, which releases heat and noxious gases and the other option is to dump it on land or in water. These are both primitive and do much harm to the environment.

Burning is called Transformation, which “refers to incineration, pyrolysis, distillation, or biological conversion other than composting.” They are very different things.

The advanced systems to burning are incineration and pyrolysis

a. Pyrolysis is the thermal break down of materials at high temperatures in an inert atmosphere. It is Greek for 'separated by fire'. It involves the change of chemical composition and is irreversible. Pyrolysis is commonly used to treat organic materials. For instance wood starts charring at 200–300 °C. It produces volatile products and leaves a solid residue enriched in carbon, char. This is called carbonization. Dry distillation, destructive distillation, cracking, and thermal depolymerization are special methods of pyrolysis. Pyrolysis is used heavily in the chemical industry to produce ethylene, many forms of carbon and other chemicals from petroleum, coal and even wood, to produce coke from coal. Ethylene is produced by steam cracking of petroleum. Pyrolysis is also used for thermal cleaning of extruder screws, spinnerets and static mix.

b. Converting plastics to diesel: Anhydrous pyrolysis converts plastic waste back into the oil from whence it came. 1 Kilogram of plastic is turned into 1 Litre of diesel instead of 3 Kilograms of CO_2. Despite how simple it looks, it is not considered very effective because it uses up a lot more energy than it creates.

c. Incineration: This is a thermal treatment where waste is burned to become flue gas, heat and ash. The ash contains mostly inorganic matter. The flue gas must be cleaned thoroughly. Incineration and pyrolysis are practiced particularly for hazardous wastes. There are stringent rules and regulations for the same. Incineration of municipal solid waste avoids the release of methane. Every ton of MSW incinerated, prevents about one ton of carbon dioxide equivalents from being released to the atmosphere (MufeedSharholy, 2008).

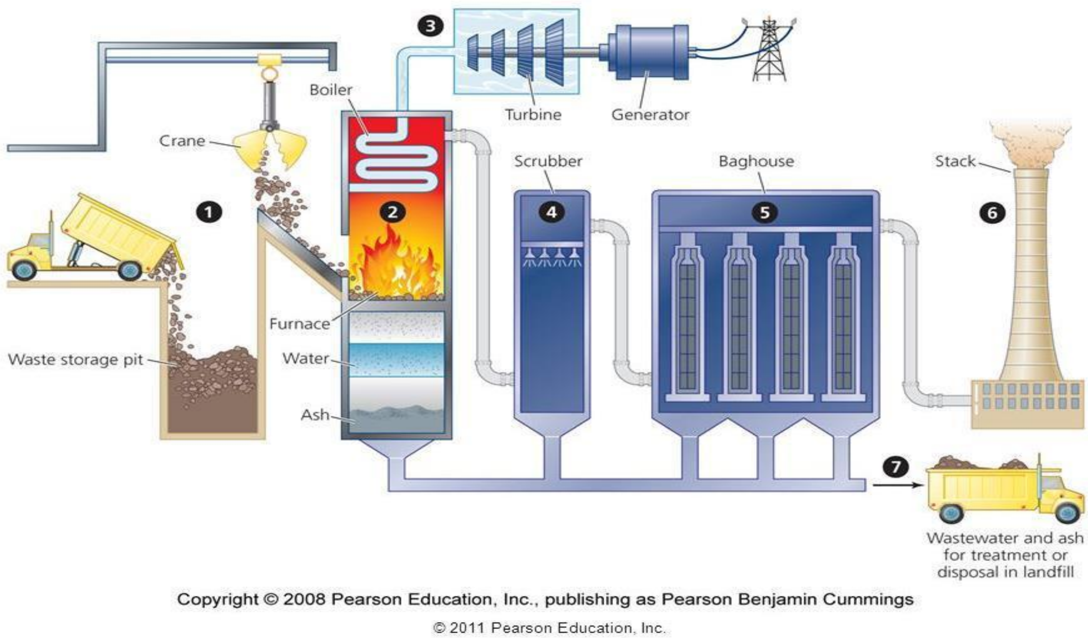


Fig 3.4 Diagrammatic Representation of a Solid Waste Incinerator (Source: MufeedSharholy, 2008)

d. Gasification: Gasification is similar to incineration in principle. Gasification produces a combustible gas. We need to maintain stringent watch on the exhaust gases, as burning of waste pollutes the atmosphere. However in Sweden, a country with several years experience in this field has proven that there are technologies available which can remove a good volume of pollutants from the flue gases resulting in a 50% cleaner exhaust.

Incineration and gasification can both be done with or without energy recovery. These three methods-incineration, pyrolysis and gasification- reduce solid mass of waste by 85% or more, incineration is particularly used in bio-medical waste management to destroy pathogens (MufeedSharholy, 2008).

There could be many health hazards connected to incineration

- Highly toxic flue gas must be safely deposited- this needs a separate specialist toxic landfill site.
- Old incinerators release furans and dioxins. They also emit varying levels of heavy metals which are toxic at the minutest level.
- Incinerator Bottom Ash is eco-toxic, with heavy metals like cadmium, vanadium, manganese, chromium, nickel, arsenic, mercury and lead present in it.
- Alternative technologies for the reuse of incinerator bottom ash are in their infancy.
- The fear of toxic air and the absence of monitoring fine and ultrafine particle emission, local people usually oppose incinerators.

Therefore, it is heartening to note that most countries that use incineration (e.g. EU, Japan) understand the hazards of incineration and keep it to the minimum. As a result they have higher recycling rates than neighbours that do not.

e. Waste to Energy

In a waste to energy facility, extremely high-temperature combustion is used to generate electricity. Emissions from the waste to energy facility are thoroughly cleaned using state-of-the-art air quality control systems. Trash brought to the waste-to-energy plant is first inspected to ensure it contains only acceptable municipal waste. The waste is deposited into a refuse pit. A crane picks up the trash from the refuse pit and loads it into hoppers. Hydraulic rams feed the trash into furnace boiler units. Heat from the burnt trash converts water in the boiler walls into steam. The high-pressure steam is routed to a turbine generator to produce electricity. Three tonnes of waste produces as much energy as one tonne of fuel oil (MufeedSharholy, 2008).

A key barrier in waste to energy is the shortage of qualified engineers and environmental professionals with the experience to deliver improved waste management systems in India.

(Watch Film: Importing garbage for energy is good business for Sweden, Duration: 4 min. https://vimeo.com/103801887)

Waste to energy plants are very clean since they filter out almost all of the dioxins and other gases that comes out of incinerators. What comes out is "99.9 per cent non-toxic carbon dioxide and water." There are many who question whether carbon dioxide is non-toxic, given its effect on the climate.

Bioremediation

Remediation of the damaged environment is part of the process of 'sustainable development' and as such a polluter is liable to pay the cost of the individual sufferers as well as the cost of reversing the damaged ecology (Fig. 3.5).

To remove, treat and dispose hazardous and non-hazardous industrial waste, a special licence is required. The technique to safely remove toxins from soil using natural methods is called bioremediation (MufeedSharholy, 2008). A two-stage solid phase bioremediation technique is employed, which involves both aerobic and anaerobic treatment stages. Explosive-contaminated soil, chemical manufacturing waste, pesticide waste, or pesticide contaminated soils, spent molecular sieve from packing towers, soils containing aliphatic chlorinated hydrocarbons, petrochemical contaminated soils, etc can be bio-remediated. For each kind of soil, the first stage comprises of mixing in a carbon source, an inoculums, vitamins and water to achieve anaerobic conditions. The basic requirements for bioremediation are:

- Microorganisms
- Energy source
- Electron acceptor
- Moisture
- pH
- Nutrients
- Temperature
- Absence of toxicity
- Removal of metabolites
- Absence of competitive organisms

The inoculum contains spores or colonies of fungi, bacteria and other microorganisms which have been tested to tolerate high level of contamination and are capable of neutralizing the contaminants. Hence the inoculum is different for each kind of contaminant.

- Aerobic bacteria such as Pseudomonas, Sphingomonas, Rhodococcus and mycobacterium are shown to degrade pesticides and hydrocarbons, alkanes and polyaromatics.
- Methanotrophs are Aerobic bacteria that use methane for energy. Methanotropsh are useful for bioremediation of ethylene dichloride.
- Anaerobic Bacteria: For polychlorinated biphenyls (PCBs) in river sediments, trichloroethylene and chloroform.

- Fungus: for persistent and toxic pollutants.

After inoculating and mixing the right ingredients for supporting the growth of the inoculums, a static pile or berm structure is created and covered. After a few months, anaerobic bacteria from the inoculums digest the toxins making the treated soil ready for the next stage, i.e. aeration. By this process of bioremediation, harmful chemicals like TNT and DDT can be removed up to 99%. Large scale remediation can be done for acetone, alcohols, benzene, toluene, xylene, 2 to 3 ring PAHs and petroleum hydrocarbon (MufeedSharholy, 2008).

In intrinsic bioremediation, the microorganisms already present on-site are used. Human intervention is not required. This is the most common and inexpensive method. When it does not work, accelerated bioremediation is applied. In this either some substrate, or nutrients are added to help break down toxic spill, allowing the microbes to grow faster. In situ treatments manage sub-surface contaminants with optimal microbial biodegradation. Local (indigenous) microbes may be used, or specialized microbes efficient in degrading the particular contaminant may be introduced (MufeedSharholy, 2008).

Accelerated bioremediation causes minimum disturbance to the site, particularly when the contaminants are moving under a permanent structure.

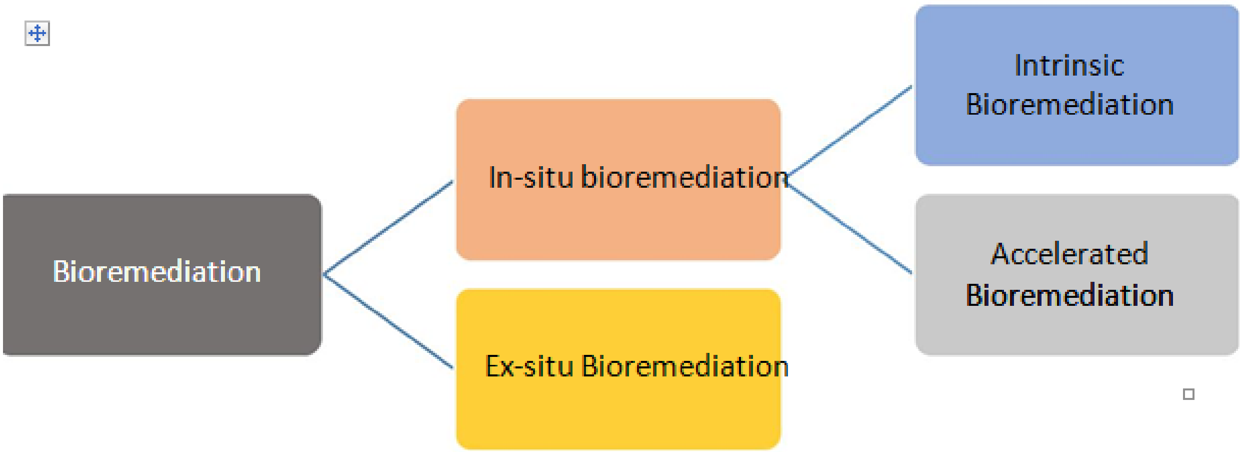


Fig 3.4 Diagrammatic Representation of a Solid Waste Incinerator (Source: MufeedSharholy, 2008)

Steps in in-situ Bioremediation:

Step 1: Site investigation

Step 2: Treatability Studies

Step 3: Recover free product, remove contamination source.

Step 4: Design and implement bioremediation system

Step 5: Monitor and evaluate performance.

Examples of In situ Bioremediation:

- Bioventing: This is the most common land treatment. Air and nutrients are supplied through wells to stimulated local bacteria.
- In-situ biodegradation: Here oxygen and nutrients are supplied by circulating an aqueous solution through contaminated soils.
- Biostimulation: Fertilizers are added to stimulate the growth of naturally present bacteria which are capable of degrading pollutants.
- Bio-augmentation: Also called 'seeding'. Bacteria are added to the contaminated soils to support indigenous microbes.
- Biosparging: Air is injected under pressure into the groundwater to increase dissolved oxygen so that the bacterial activity is accelerated. Biosparging increases contact between soil and groundwater.
- Natural Attenuation.
- Rhizofiltration
- Examples of Ex-situ Bioremediation:
- Land farming: Excavated contaminated soil is spread over a prepared bed and periodically tilled.
- Composting: Non-hazardous organic wastes like agricultural residues are mixed in and allowed to degrade together. Elevated temperatures and rich microbial growth accelerate the degradation.
- Bio-piles:
- Bio-reactors: for slurry based contaminants. Here water, oxygen and fertilizer is mixed into the slurry for degrading pollutants.

When contaminated soil is transferred for cleaning up, it is ex-situ bioremediation. This is expensive and damages the area, since the soil is physically removed.

Bioremediation is limited to those compounds that are biodegradable. Sometimes the resultant product may be more persistent than the parent compound (Fig. 3.6). It is a longer process. A suitable environment must be given to the microbes- nutrients as well as contaminants. Sometimes genetically engineered microbial strains are applied, such as petroleum eating bacterial-Pseudomonas with encoded genes for breaking up pollutants. Or, Escherichia coli used to clean heavy metals - mercury, chromium and cadmium. Certain bacteria are used as indicators, or 'biosensors' to judge the presence of certain environmental pollutants. Certain phytoremediation (plant based bioremediation) can remove TNT.

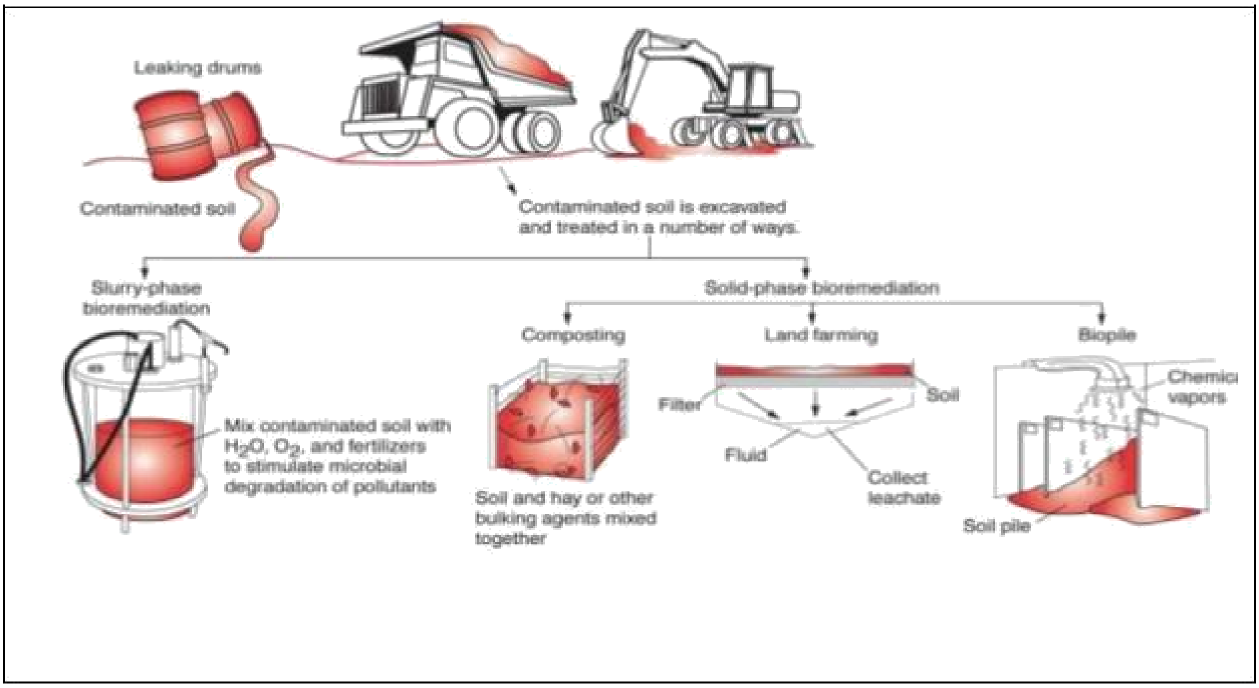


Fig 3.6 Methods of Ex-situ Bioremediation (Source: Azeem (2013) Bioremediation-of-contaminated-soils)

Compaction

Waste compaction is done to compress the waste in a landfill to reduce volume and extend the lifespan of a landfill (Fig. 3.7). A landfill compactor rolls over layers of flattened waste at least thrice to eliminate voids (Sunil Kumar, 2017). The remaining waste, which has no further use could include inert waste, non-recyclable plastics, textile waste, composite material for which recycling technology is yet to be invented. A combined study by SAARC, NEEERI and the Royal Society has established that reliance on waste dumps is neither sustainable nor environmentally safe for fast-growing cities (Sunil Kumar, 2017).

Fig 3.7 Landfill Compactor (Source: Challenges and opportunities associated with waste management in India. Sunil Kumar et al, Mar 2017. http://rsos.royalsocietypublishing.org/content/4/3/160764.)

This film explains total waste management achieved by the industrial town of Nashik, Maharashtra.

(Watch Film: Nashik Waste Management, Dur: 6 min: https://www.youtube.com/watch?v=JXmDJtJ-mMw)

Landfill

In most cases disposal sites are located in environmentally sensitive, low-laying areas such as wetlands, forest edge or adjacent to bodies of water. They often do not have liners, fences, soil covers and compactors. When waste breaks down in landfills it creates methane – a greenhouse gas and leachate – a toxic liquid. Methane is 25 times more potent than carbon dioxide as a greenhouse gas. Leachate is highly toxic. It pollutes the surrounding ground and can find its way into rivers and oceans. Each year the amount of waste we throw away increases by 3%. This means by 2025, the waste we produce will have doubled (Sunil Kumar, 2017).

Engineered Landfill: An engineered landfill is an engineered system designed for safe, environmentally sound long-term waste disposal. Trash is deposited in the landfill and compacted. The landfill's liner as well as gas and leachate extraction system protect the surrounding land, air and water. Operating procedures include regular environmental monitoring. Residential and commercial waste is transported to a waste management landfill for permanent disposal. Much of this waste including food, paper, cardboard, is organic in nature. Bacteria digest this organic waste and produce methane gas and carbon dioxide as natural by-products. The methane gas is recovered via a series of wells drilled into the landfill. These wells are connected by a common pipe system that collects the gas and delivers it to a fuel conditioner. The gas is piped to an electricity generation plant, on- or off-site (Sunil Kumar, 2017).

Though technically sound and a great improvement from waste dumps, yet landfills are is not the most sustainable method of disposing waste. Landfills need constant monitoring and are expensive to build. Hence, they are not popular in India (Sunil Kumar, 2017). For any solid waste management enterprise, the aim should be to make garbage reaching the dumpsite to a bare minimum. As recycling and waste minimization gain attention, the amount of organic waste in landfill sites is bound to be low too. With only inert materials sent to a landfill, it will take several years to settle and very minimum methane will be generated (Sunil Kumar, 2017).

Bioreactor Landfills: To better the system, bioreactor landfills are considered the future of landfill management. Instead of being secured waste repositories, landfills can be turned into waste treatment systems through bioremediation. The most important condition to promote waste decomposition is moisture content. Landfill leachates, gas condensates, waste water treatment sludge and storm water runoff can be added to maintain moisture. Leachate recirculation not only reduces leachate management cost, but also improves leachate quality. Bioreactor landfill process is still under development. Four types of technologies can be used: aerobic-anaerobic, anaerobic, aerobic and facultative. The process can be retrofitted to old landfills as well as to new ones. In India, we do not have many engineered landfills. The challenge is to stabilize our garbage dumps with minimal pollution (Sunil Kumar, 2017).

Capping of Waste

The final act to be done in garbage disposal is capping. Caps do not destroy or remove contaminants. Instead, they isolate them and keep them in place to avoid the spread of contamination. Therefore, just before capping, the waste heap needs to be bio-remedied. Various inoculums containing fungi and bacteria are added to the soil, which helps to capture or breakdown any toxic materials to leave the waste inert. The entire heap is compacted by heavy machinery benched and sloped and then covered with multiple layers of soil, silt, geo-textiles and finally topsoil. The gradient of the slopes should be gentle. This artificial hill is then vegetated at first by fast growing tree species. As the vegetation flourishes, more indigenous tree species are planted till the entire area is naturalized. It takes around 15 years to re-wild? the dump yard. The process is similar to that of rehabilitating mining waste.

Waste dumps are big eyesores for nearly every city. Under the Swachh Bharat Abhiyan an effort is being made to cap legacy waste dumps. Legacy dumps are those waste dumps, from which most of the recyclables have been recovered and now no waste added. After a few years of stabilization, they need to be capped to prevent water pollution due to leachate draining out after the monsoons. This is a major operation (Sunil Kumar, 2017).

3.4 Composting

Segregated waste is a valuable resource. Once the waste has been segregated into different categories, it moves for processing, sometimes in situ, at other times to a different location. This component of waste management generates revenue. Value extraction can be materials, energy or nutrients and this can provide a livelihood for many people. At least eighty per cent of waste generated by an average person is recyclable. If not properly recycled, majority of it ends up in landfills. This amounts to one and a half ton per person every year- equivalent to the weight of a small car.

Fig. 3.8 ISWM Hierarchy (Jibril, 2012)

After waste minimisation and recycling systems, the ISWM hierarchy indicates adoption of resource recovery strategies and composting as the third preferred waste management practice, ensuring that waste is processed appropriately to facilitate further use of the material (L. Chen, 2012). Composting is a controlled aerobic process of biologically "digesting" the municipal solid waste, so it may be recycled for other purposes – plant nutrient, stabilization of soil in remediation process or soil amendment for recovery of poor soils (L. Chen, 2012).

Compost production can be carried out at the decentralized level (home composting/bin composting/box composting/vermicomposting/in-vessel composting) or at a centralized level (windrow composting/in-vessel composting/aerated static pile), depending upon the feasibility of implementation. Both processes required significant pre-processing and only organic matter is to be composted (L. Chen, 2012).

Compost produced should meet with quality criteria specified by the MSW Rules and the Fertilizer Control Order 2009 and 2013. A market for the compost should be ascertained before sizing the compost plants. Municipal Solid Waste primarily consists of organic, inorganic and inert fractions. Under natural conditions, the organic fraction of waste continually decomposes, accompanied by a strong foul odour and production of gases, predominantly methane or carbon dioxide depending upon the aerobicity of the decomposing mass. Vector infestation during the natural decomposition process is a common phenomenon (L. Chen, 2012).

Composting is a process of controlled decomposition of the organic waste, typically in aerobic conditions, resulting in the production of stable humus like product, compost. Considering the typical composition of wastes and the climate conditions, composting is highly relevant in India and should be considered in all MSWM concepts. Composting of the segregated wet fraction of waste (see chapter2 of Part II of this manual) is preferred (L. Chen, 2012). Mixed waste composting, with effective and appropriate pre-treatment of feedstock may be considered an interim solution; in such cases stringent monitoring of the compost quality is essential.

Benefits of Composting

The real economic benefits of compost use include improved soil quality, enhanced water retention capacity of soil, increased biological activity, micro-nutrient content and improved pest resistance in crops(L. Chen, 2012).

- Composting minimizes/avoids GHG emissions from anaerobic decomposition of organic waste (such as in a large unturned heap).
- Composting increases the design life of other waste management facilities
- Stringent design requirements and associated costs for catering to management of leachates from organic waste decomposition may be reduced in those landfills that do not receive organic waste (so far not in MSW Rules).
- Compost is particularly useful as organic manure as it contains macro plant nutrients (Nitrogen, Phosphorous and Potassium) as well as micro nutrients. When used in conjunction with chemical fertilizers optimum results are obtained.
- The use of compost reduces the dependency on chemical fertilizers (availability as well as quantity) for agricultural operations. When used as a soil amendment, compost reduces the

need for water, fertilizers, and pesticides. Compost acts as a soil conditioner, therefore supporting the long term fertility of soil.

- Compost may be used to revitalize vegetation habitats and add life to marginal, impoverished soils

Compost may also be used as a bio matrix in remediation of chemical contaminants and as a remediation soil in contaminated sites as compost helps in binding heavy metals and other contaminants, reducing leachability and bio-absorption (L. Chen, 2012).

Aerobic Composting (Fig. 3.9)

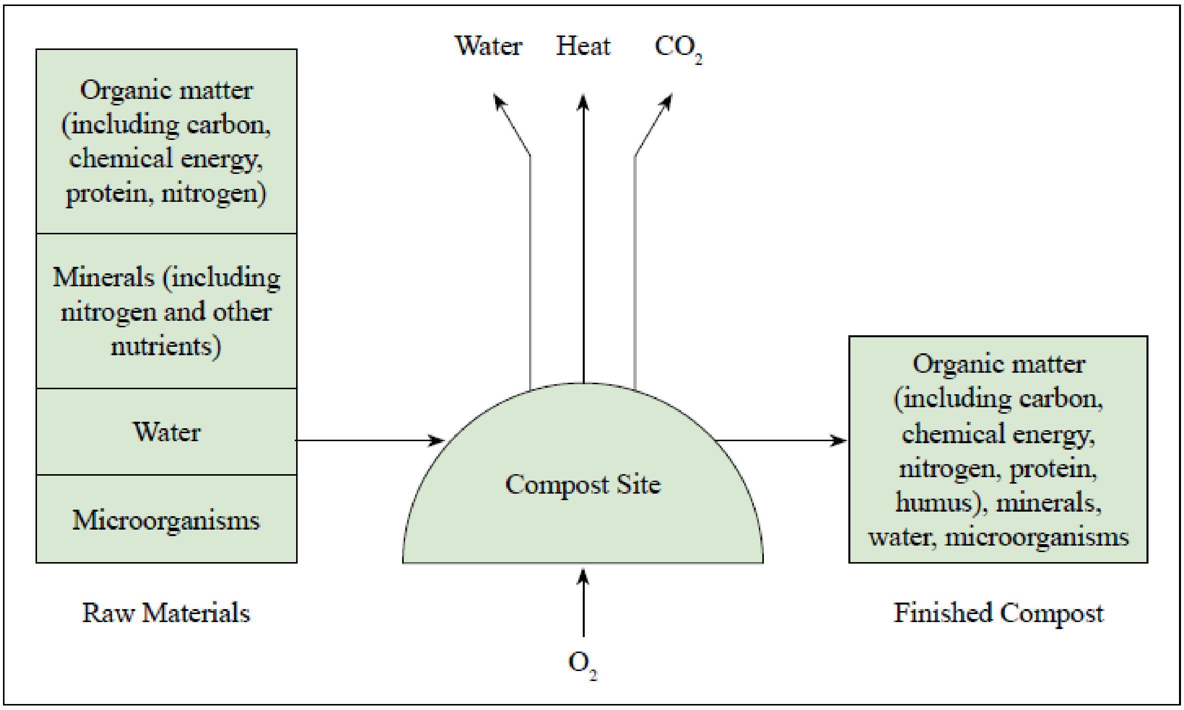


Fig. 3.9 Process of Aerobic Composting (Source: L. Chen, 2012)

During aerobic composting, micro-organisms oxidize organic compounds to Carbondioxide, Nitrite and Nitrate. Carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to chemical reactions producing heat, temperature of the ass rises.

Several biological, chemical and physical processes contribute to the success of the aerobic composting (Figure 3.10). Understanding these processes is necessary for making informed decisions when developing and operating a composting program

There are five main areas that must be "controlled" during composting (L. Chen, 2012).

1. Feedstock and Nutrient Balance

Composting, or controlled decomposition, requires a proper balance of "green" organic materials and "brown" organic materials. "Green" organic material includes grass clippings, food scraps, and manure, which contain large amounts of nitrogen. “Brown” organic materials includes dry leaves, wood chips, and branches, which contain large amounts of carbon but little nitrogen. Obtaining the right nutrient mix requires experimentation and patience. It is part of the art and science of composting.

2. Particle Size

Grinding, chipping, and shredding materials increases the surface area on which microorganisms can feed. Smaller particles also produce a more homogeneous compost mixture and improve pile insulation to help maintain optimum temperatures (see below). If the particles are too small, however, they might prevent air from flowing freely through the pile.

3. Moisture Content

Microorganisms living in a compost pile need enough moisture to survive. Water is the key element that helps transports substances within the compost pile and makes the nutrients in organic material accessible to the microbes. Organic material contains some moisture in varying amounts, but moisture also might come in the form of rainfall or intentional watering.

3. Oxygen Flow

Turning the pile, placing the pile on a series of pipes, or including bulking agents such as wood chips and shredded newspaper all help aerate the pile. Aerating the pile allows decomposition to occur at a faster rate than anaerobic conditions. Care must be taken, however, not to provide too much oxygen, which can dry out the pile and impede the composting process.

4. Temperature:

Microorganisms require a certain temperature range for optimal activity. Certain temperatures promote rapid composting and destroy pathogens and weed seeds. Microbial activity can raise the temperature of the pile’s core to at least 140° F. If the temperature does not increase, anaerobic conditions (i.e., rotting) occur. Controlling the previous four factors can bring about the proper temperature.

5. Onsite Composting

Organizations that are going to compost small amounts of wasted food can compost onsite. Composting can significantly reduce the amount of wasted food that is thrown away. Yard trimmings and small quantities of food scraps can be composted onsite. Animal products and large quantities of food scraps are not appropriate for onsite composting (L. Chen, 2012).

Things to Think About

- The climate and seasons changes will not have a big effect on onsite composting. Small adjustments can be made when changes happen such as when the rainy season approaches.
- Food scraps need to be handled properly so they don’t cause odors or attract unwanted insects or animals.

- Onsite composting takes very little time or equipment. Education is the key. Local communities might hold composting demonstrations and seminars to encourage homeowners or businesses to compost on their own properties.
- Creating compost can take up to two years, but manual turning can speed up the process to between three to six months.
- Compost, however, should not be used as potting soil for houseplants because of the presence of weed and grass seeds.
- You can leave grass clippings on the lawn-known as "grasscycling." These cuttings will decompose naturally and return some nutrients back to the soil, similar to composting.
- You can put leaves aside and use them as mulch around trees and scrubs to retain moisture.

b) Vermicomposting

Red worms in bins feed on food scraps, yard trimmings, and other organic matter to create compost. The worms break down this material into high quality compost called castings. Worm bins are easy to construct and are also available for purchase. One pound of mature worms (approximately 800-1,000 worms) can eat up to half a pound of organic material per day. The bins can be sized to match the volume of food scraps that will be turned into castings (L. Chen, 2012).

It typically takes three to four months to produce usable castings. The castings can be used as potting soil. The other byproduct of vermicomposting known as "worm tea" is used as a high-quality liquid fertilizer for houseplants or gardens (L. Chen, 2012).

Note: Night-crawlers and field worms found in gardens are not appropriate for vermiculture.

What Can Be Composted - Vermiculture?

- Food scraps
- Paper
- Yard trimmings such as grass and plants
- Things to Think About:
- Ideal for apartment dwellers or small offices.
- Schools can use vermiculture to teach children conservation and recycling.
- It is important to keep the worms alive and healthy by providing the proper conditions and sufficient food.
- Prepare bedding, bury garbage, and separate worms from their castings.
- Worms are sensitive to changes in climate.
    - Extreme temperatures and direct sunlight are not healthy for the worms.
    - The best temperatures for vermicomposting range from 55° F to 77° F.
    - In hot, arid areas, the bin should be placed under the shade.

- Vermicomposting indoors can avoid many of these problems.

c) Aerated (Turned) Windrow Composting

Aerated or turned windrow composting is suited for large volumes such as that generated by entire communities and collected by local governments, and high volume food-processing businesses (e.g., restaurants, cafeterias, packing plants). It will yield significant amounts of compost, which might require assistance to market the end-product. Local governments may want to make the compost available to residents for a low or no cost (L. Chen, 2012).

This type of composting involves forming organic waste into rows of long piles called “windrows” and aerating them periodically by either manually or mechanically turning the piles. The ideal pile height is between four and eight feet with a width of 14 to 16 feet. This size pile is large enough to generate enough heat and maintain temperatures. It is small enough to allow oxygen flow to the windrow's core.

Large volumes of diverse wastes such as yard trimmings, grease, liquids, and animal byproducts (such as fish and poultry wastes) can be composted through this method (L. Chen, 2012).

Things to Think About

- Windrow composting often requires large tracts of land, sturdy equipment, a continual supply of labor to maintain and operate the facility, and patience to experiment with various materials mixtures and turning frequencies.
- In a warm, arid climate, windrows are sometimes covered or placed under a shelter to prevent water from evaporating.
- In rainy seasons, the shapes of the pile can be adjusted so that water runs off the top of the pile rather than being absorbed into the pile.
- Windrow composting can work in cold climates. Often the outside of the pile might freeze, but in its core, a windrow can reach 140° F.
- Leachate is liquid released during the composting process. This can contaminate local ground water and surface-water supplies. It should be collected and treated.
- Windrow composting is a large-scale operation and might be subject to regulatory enforcement, zoning, and siting requirements. Compost should be tested in a laboratory for bacterial and heavy metal content.
- Odors also need to be controlled. The public should be informed of the operation and have a method to address any complaints about animals or bad odors.

d) Aerated Static Pile Composting

Aerated static pile composting produces compost relatively quickly (within three to six months). It is suitable for a relatively homogenous mix of organic waste and work well for larger quantity generators of yard trimmings and compostable municipal solid waste (e.g., food scraps, paper products), such as local governments, landscapers, or farms. This method, however, does not work well for composting animal byproducts or grease from food processing industries (L. Chen, 2012).

In aerated static pile composting, organic waste mixed in a large pile. To aerate the pile, layers of loosely piled bulking agents (e.g., wood chips, shredded newspaper) are added so that air can pass from the bottom to the top of the pile. The piles also can be placed over a network of pipes that deliver air into or draw air out of the pile. Air blowers might be activated by a timer or a temperature sensors(L. Chen, 2012).

Things to Think about

- In a warm, arid climate, it may be necessary to cover the pile or place it under a shelter to prevent water from evaporating.
- In the cold, the core of the pile will retain its warm temperature. Aeration might be more difficult because passive air flowing is used rather than active turning. Placing the aerated static piles indoors with proper ventilation is also sometimes an option.
- Since there is no physical turning, this method requires careful monitoring to ensure that the outside of the pile heats up as much as the core.
- Applying a thick layer of finished compost over the pile may help alleviate any odors. If the air blower draws air out of the pile, filtering the air through a biofilter made from finished compost will also reduce any of the odors.
- This method may require significant cost and technical assistance to purchase, install, and maintain equipment such as blowers, pipes, sensors, and fans.

Having a controlled supply of air allows construction of large piles, which require less land than the windrow method (L. Chen, 2012).

e) In-Vessel Composting

In-vessel composting can process large amounts of waste without taking up as much space as the windrow method and it can accommodate virtually any type of organic waste (e.g., meat, animal manure, biosolids, food scraps). This method involves feeding organic materials into a drum, silo, concrete-lined trench, or similar equipment. This allows good control of the environmental conditions such as temperature, moisture, and airflow. The material is mechanically turned or mixed to make sure the material is aerated. The size of the vessel can vary in size and capacity (L. Chen, 2012).

This method produces compost in just a few weeks. It takes a few more weeks or months until it is ready to use because the microbial activity needs to balance and the pile needs to cool.

Things to Think About

- Some are small enough to fit in a school or restaurant kitchen.
- Some are very large, similar to the size of school bus. Large food processing plants often use these.
- Careful control, often electronically, of the climate allows year-round use of this method.
- Use in extremely cold weather is possible with insulation or indoor use.
- Very little odor or leachate is produced.
- This method is expensive and may require technical expertise to operate it properly.
- Uses much less land and manual labor than windrow composting (L. Chen, 2012).

3.3 Preventive Maintenance

Preventive maintenance is an essential part of the operation of collection equipment and transportation vehicles to ensure maximum life of the equipment and fleet life is at its maximum capacity most of the time. However, there is a need to make a clear distinction between preventive maintenance – which is carried out at a defined and disciplined schedule – and crisis (or breakdown) maintenance which is only carried out when a fault develops(Municipal solid waste management manual, Govt of India, 2014).

Good preventive maintenance starts with the selection and specification of appropriate vehicles and equipment. Vehicles should be well suited to pre-defined requirements, localized conditions and should be procured after ascertaining ease of availability of spare parts. Cost of spares should be considered while making purchase decisions. Local availability of spare parts is often associated with reliability. Preventive maintenance schedule must be notified well in advance to all concerned and should be strictly enforced(Municipal solid waste management manual, Govt of India, 2014).

Benefits of Preventive Maintenance

- ➢ An important aspect of a planned preventive maintenance programme is that it helps to take corrective measures well in advance, anticipate faults and prevent a major break down which could endanger the safety of the personnel and entail huge cost implications.
- ➢ A preventive maintenance programme gives advance notice of any requirement for spare parts, ensuring that equipment/vehicles are not out of service while the parts are being obtained in due course of time.
- ➢ A planned preventive maintenance programme will not only keep existing equipment operating at its maximum efficiency but will also provide requisite information to financial planners, enabling them to include accurate forecasts of required expenditures for repairs , maintenance and replacement of vehicles and equipment.
- ➢ Preventive maintenance programmes change the institutional culture of the municipal administration; breakdowns are no longer seen as a regular matter(Municipal solid waste management manual, Govt of India, 2014).

Accountability & Responsibility for Preventive Maintenance

Preventive maintenance imposes responsibility and accountability at various levels, such as drivers, store in-charges, mechanics and the workshop manager, for breakdowns and delays in repairs after a breakdown. Delays in procuring spares may also be due to lack of funds for purchasing essential parts, for which the financial controller/officer may be accountable(Municipal solid waste management manual, Govt of India, 2014).

Example of a Preventive Maintenance Schedule for Vehicles

- Daily checks by drivers
- Weekly servicing checks by a junior mechanic will highlight issues which a driver may not be able to identify and/or indicate if the daily checks are not effective
- Monthly service check by a senior mechanic shall reveal any inadequacies in the weekly checks
- The six monthly checks identify issues which have not been identified/addressed by the monthly checks

The success of a preventive maintenance programme is indicated by fleet and equipment availability on any day. The success can also be indicated by calculating the number of vehicles (perhaps of a particular type) that are ready for service on any particular day, divided by the total number of vehicles in the current fleet. The numbers could indicate the condition of the vehicles and whether the maintenance programme is improving or weakening (Municipal solid waste management manual, Govt of India, 2014).

Management personnel should periodically review this information to refine maintenance plans for particular vehicles and to identify improvements to the overall maintenance program. Similar systems should be in place for monitoring the downtimes and availability of other equipment and machinery used for all SWM activities. MSW processing, treatment and disposal facilities should be encouraged to maintain relevant records to ensure minimum down time of machinery (Municipal solid waste management manual, Govt. of India, 2014).

3.5 General Process of Recycling

Packaging waste is an omnipresent content of garbage. The consumer pays up to 16% of the total product price on packaging alone. 15 million 'single-use' plastic bottles are used every day. Nearly half this amount ends up in landfills. Plastic can take up to 500 years to decompose. An average family throws away the equivalent of 6 trees a year. Recycling is defined as "Using waste as material to manufacture a new product." Recycling involves altering the physical form of an object or material and making a new object from the altered material (Dong, 2016).

Recycling packaging waste can bring down the cost of packaging as recycling saves energy and resources. Glass, plastic, paper and metals are the main recyclable materials. One recycled tin can save enough energy to power a TV for 3 hours. One recycled plastic bottle saves enough energy to power a light bulb for 3 hours. The oil it takes to make one plastic bag could be used to fuel a car for 11 metres. A single recycled glass bottle saves enough energy to power a computer for 25 minutes. It takes 50 times more energy to make one battery than the energy produced by that battery.

Collection trucks bring recyclables to a recycling facility, where they are unloaded on a tipping floor. Often this is a single stream facility, since collecting different recyclable materials as individual streams can be logistically difficult. The single stream facility makes recycling easier for everyone in the community. In larger facilities, recyclables are placed on a conveyor belt, from which they are sorted by machine or hand into broad categories of paper, plastic, glass and metal (Dong, 2016).

1. Paper recyclables are separated into four categories: Old newspaper, corrugated boxes, mixed paper and office mix.

2. Plastics are sorted by colour and type. Air is blown into the mix to separate heavier and lighter plastics. Sometimes they are optically scanned for separation into types e.g. PET, HSPE, etc.

3. Glass is crushed into cullet, and then cleaned of debris and contaminants. Sometimes, glass may be sorted by colour before (or after) crushing or it may be shipped directly to the end-user without sorting.

   Cullet is loaded onto trucks for transport to customers. Glass cullet can be used for making new containers, consumer products, road bedding, sand blasting, counter-tops, etc. To make new containers, the cleaned cullet is mixed with soda ash, sand, feldspar and limestone at a glass plant(Dong, 2016).

   The mixture is heated at 1500^{o}C to mould new products. Using recycled glass reduces emissions, energy use, raw material and also extends the life of the plant equipment.

4. Metals: Magnets are used to separate steel from the rest of the stream. Steel is stored separately for baling. Aluminium is mechanically separated by eddy current (if it is the form of cans).

Aluminium cans are crushed and baled separately. They are sent to the respective customers. At the aluminium plant, aluminium is melted and poured into ingot moulds or rolled into sheets to make new products such as window frames, cans, etc. At the steel mill, tin and steel are recovered through chemical and electrolysis baths. They are purified, melted and cast into ingots. Household hazardous waste (HHW) includes items that we use in our daily lives that contain potentially hazardous ingredients and require special care for disposal. When these products are not properly disposed of, harmful chemicals can be released into the environment and contaminate air, water, and the food we eat. Below is a list of items that are considered to be HHW and should be properly disposed of at an authorized collection site (Dong, 2016).

- Batteries: single use and rechargeable
- E-waste: televisions, computers, and other electronic devices
- Mercury-containing items: fluorescent lamps or tubes, thermometers
- Household and landscape chemicals: flammables, non-empty aerosol cans, cleaners, and pesticides
- Paints and solvents: latex and oil-based paint, paint thinners, and nail polish remover
- Building Materials: asbestos and treated wood
- Automobile related: antifreeze, batteries, motor oil and filters, tires
- Medicines

3.6 Precautions for Recycling

It is vital to keep the recycling stream clean. Education plays a key role in this to teach and remind staff and tenants how to maintain the recycling programmes. Training sessions, periodic talks, newsletters, events or competitions centred on recycling goals are essential (Dong, 2016).

Small mistakes can contaminate the recyclable stream, such as food wastes or liquids being discarded in the recyclable bins. Forbidden material include shredded paper, corrosive batteries, pizza boxes blotched with cheese and grease, plastic wrappers for food, unclean jam jars, broken glass, un-rinsed bottles, paper envelopes with plastic address-windows and newspapers that have been used for other purposes. Ordinarily, recyclable waste stream comes with 15-25 percent contamination. For proper recycling with least effort, the waste stream should have less than 1 percent contamination. Here, the model adopted by the zero-waste village of Kamikatsu in south western Japan, seems to be a sustainable solution (Dong, 2016).

If the recyclable waste stream is too contaminated, it runs the risk of not being recovered, but being completely trashed. Recyclers these days do not want items with mixed material such as paper and plastic, or cardboard and tape. It doesn’t pay to tear the stuff apart. Such mixed recyclable waste is simply sent off to the landfill.

In many cases recycling does not generate enough money. Scrap value has dropped — especially for plastic. When oil prices tumbled, it became cheaper to make plastic bottles from all-new material than recycled matter.(Watch Film 4 How Sweden turns its waste into gold: Duration 20 min: https://www.youtube.com/watch?v=14r7f9khK70)

Aluminium

Aluminium cans must be rinsed out before sending. Recyclable aluminium has the code: 41-ALU. Aluminium Foil can also be recycled, if clean. Aluminium cans are 100 percent recyclable. This means every tin can you recycle ends up back on the shelves within 60 days.

Glass

Clear glass should be sent separate from coloured glass. Some recycling centres have three streams for-clear, green and brown glass. 70- GL is mixed or multi part glass. 71 GL is clear glass while 72 Gl stands for green glass. Mixing glass streams interferes with its uniform melting.

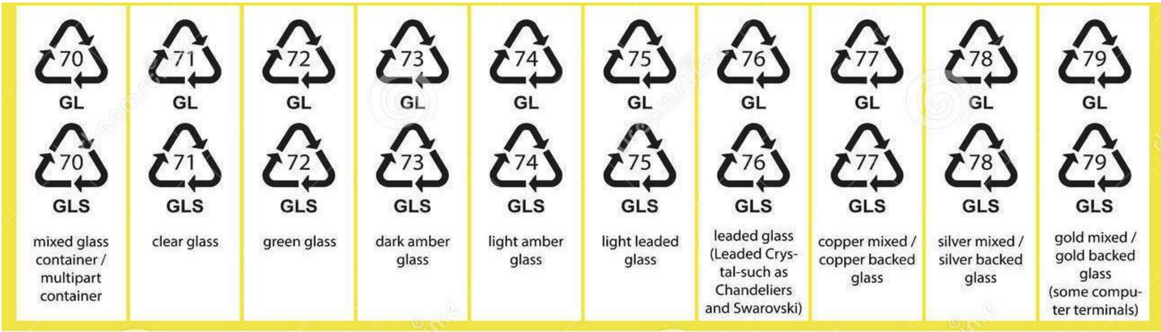


Fig 3.10 International Symbols for Glass Recycling (Source: Recyclenow, 2014)

3.4 Precautions while Recycling Plastics

Threat of Plastics

As of 2018, about 380 million tonnes of plastic is produced worldwide each year. Less than 25 percent of this is recycled, the rest is incinerated or put into landfills and oceans. Leaching of chlorinated plastic can release harmful chemicals into the surrounding soil, which can then seep into groundwater and surface water bodies. An estimated 1.15 to 2.41 million tonnes of plastic enters the oceans via rivers. The top 20 contributing rivers are mostly found in Asia and deliver around 67 percent of all plastics flowing into the oceans. Plastics that reach the oceans degrade much slower than on land. It is estimated that a foam cup takes 50 years, a plastic beverage holder 400 years, a diaper 450 years and fishing line 600 years to degrade. Today there are 5 major gyres of plastic (marine debris particles) in the ocean, which resemble a diffuse soup of plastic floating in the waters. The Great Pacific garbage patch in the central North Pacific Ocean a.k.a. the Pacific trash vortex, is the largest of them –about 1.6 million sq. km. The carcasses of 90 percent of seabirds and marine turtles reveal plastic debris. Researchers suggest that by 2050 there could be more plastic than fish in the oceans by weight.

Plastic recycling is a complicated affair. The well-recognized "chasing arrows" symbol we see on plastic containers and products does not mean the product is recyclable. The number inside the triangle – 1 to 7- helps to identify the type of plastic used for the product, and not all plastics are recyclable or even reusable. It is important to understand the seven plastic codes. For example, water bottles that display 3 or 5 cannot be recycled in most areas (Hopewell, 2009).

#1 - PET (Polyethylene Terephthalate)

PET is one of the most commonly used plastics in consumer products, and is found in most water and soft drink bottles and some packaging. It is intended for single use applications; repeated use increases the risk of leaching and bacterial growth. PET plastic is difficult to decontaminate and proper cleaning requires harmful chemicals. Polyethylene terephthalates may leach carcinogens (Hopewell, 2009).

Products made of #1 (PET) plastic should be recycled but not reused. About 25 percent of PET bottles are recycled. The plastic is crushed and then shredded into small flakes which are then reprocessed to make new PET bottles, or spun into polyester fiber. This recycled fiber is used to make textiles such as fleece garments, carpets, stuffing for pillows and life jackets, and similar products. India has pledged to phase out single-use plastic by 2022.(Watch Film 5 How to turn plastic bottles into clothes. Duration 5.30 min: https://www.youtube.com/watch?v=zyF9MxlcItw)

#2 - HDPE (High-Density Polyethylene)

HDPE plastic is the stiff plastic used to make milk jugs, detergent and oil bottles, toys and some plastic bags. HDPE is the most commonly recycled plastic and is considered one of the safest forms of plastic. It is a relatively simple and cost-effective process to recycle HDPE plastic for secondary use (Hopewell, 2009).

HDPE plastic is very hard-wearing and does not break down under exposure to sunlight or extremes of heating or freezing. For this reason, HDPE is used to make picnic tables, plastic lumber, waste bins, park benches, bed liners for trucks and other products which require durability and weather-resistance (Banerjee and Srivastava, 2014).

#3 – PVC (Polyvinyl Chloride)

PVC is a soft, flexible plastic used to make clear plastic food wrapping, cooking oil bottles, teething rings, children’s and pets’ toys and blister packaging for myriad consumer products. It is commonly used as the sheathing material for computer cables and to make plastic pipes and parts for plumbing. Because PVC is relatively impervious to sunlight and weather, it is used to make window frames, garden hoses, arbors, raised beds and trellises (Hopewell, 2009).

PVC is dubbed the “poison plastic” because it contains numerous toxins which it can leach throughout its entire life cycle. Almost all products using PVC require virgin material for their construction; less than 1 percent of PVC material is recycled. Products made using PVC plastic are not recyclable. While some PVC products can be repurposed, PVC products should not be reused for applications with food or for children’s use. The Table 3.1 below summarizes the use and dangers of each plastic category (Hopewell, 2009).

#4 – LDPE (Low-Density Polyethylene)

LDPE is often found in shrink wraps, dry cleaner garment bags, squeezable bottles and the type of plastic bags used to package bread. The plastic grocery bags used in most stores today are made using LDPE plastic. Some clothing and furniture stores also uses this type of plastic.

LDPE is considered less toxic than other plastics, and relatively safe for use. It is not commonly recycled, however, although this scenario is changing in many communities today as more plastic recycling programs gear up to handle this material. When recycled, LDPE plastic is used for plastic lumber, landscaping boards, garbage can liners and floor tiles. Products made using recycled LDPE are not as hard or rigid as those made using recycled HDPE plastic. Products made using LDPE plastic are reusable, but not always recyclable. You need to check with your local collection service to see if they are accepting LDPE plastic items for recycling (Hopewell, 2009).

Table 3.1 Recyclability and Dangers of Plastics by Category

Number	Type	Reusable	Recyclable	Cancer-ous	Avoid	Remarks
1- PETE **(Polyethylene terephthalate)**	One-time use. Mineral water bottles. Oil bottles	No	Yes	Yes	Yes	Leaching, bacterial growth
2- HDPE **(High density polyethylene)**	Stiff plastic e.g Shampoo bottles,	Yes	Yes	No	No	Safest
3- PVC **(Polyvinyl Chloride)**	Soft, flexible Eg. Blister packing, toys, garden hose	Yes but don't reuse for food or children	No	Yes	Yes	"Poison plastic" It leaches
4- LDPE **(Low density polyethylene)**	Shrink wrap, bread packets,	Yes	Yes Sometimes	No		Safe
5- PP	Tough, light	Yes	Yes	No		Not accepted in

(Poly-propylene)	weight, heat resistant. eg diapers, bottle caps, rope, packing tape.					most recycling centres
6- PS **(Polystyrene)**	Cheap, Weak Lightweight, e.g. Styrofoam cups	No foam packing may be reused	Yes. But expensive, most organizations choose not to recycle	Yes	Yes	Leaches, Bad for reproductive organs
7-Others	BPA, Polycarbonate, LEXAN	No	Pla / Compostable plastics only can be recycled	No	Yes. Avoid for foods.	Leaching, Endocrine disruption
ABS **(acrylonitrile butadiene styrene)**	Hard, sturdy, durable plastics e.g. appliances, computers, and cell phones	No	Yes	No	No	Thermoplastics can be melted and re-moulded into new ABS materials. This cannot be done indefinitely like glass.

#5 – PP (Polypropylene)

Polypropylene plastic is tough and lightweight, and has excellent heat-resistance qualities. It serves as a barrier against moisture, grease and chemicals. PP is also commonly used for disposable diapers, pails, plastic bottle tops, margarine and yogurt containers, potato chip bags, straws, packing tape and rope. Polypropylene is recyclable through some curbside recycling programs but only about 3 percent of PP products are currently being recycled in the United States of America (USA). Recycled PP is used to make landscaping border stripping, battery cases, brooms, bins and trays. However, #5 plastic is today becoming more accepted by recyclers. PP is considered safe for reuse (Hopewell, 2009).

.#6 – PS (Polystyrene)

Polystyrene is an inexpensive, lightweight and easily-formed plastic with a wide variety of uses. It is most often used to make disposable styrofoam drinking cups, take-out “clamshell” food containers, egg cartons, plastic picnic cutlery, foam packaging, etc. Polystyrene is also widely used to make rigid foam insulation and underlay sheeting for laminate flooring used in home construction (Banerjee and Srivastava, 2014).

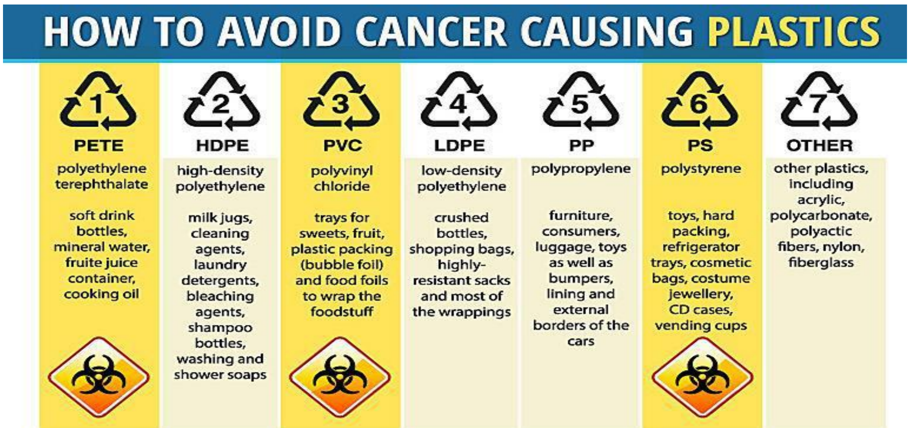


Fig: 3.11 International Symbols for Plastic Segregation (Source: Diwakar, 2018)

Because polystyrene is structurally weak and ultra-lightweight, it breaks up easily and is dispersed readily throughout the natural environment. Beaches all over the world have bits of polystyrene lapping at the shores, and an untold number of marine species have ingested this plastic with immeasurable consequences to their health (Hopewell, 2009).

Polystyrene may leach styrene, a toxin that is possibly a carcinogen, into food products (especially when heated in a microwave). Chemicals present in polystyrene have been linked with reproductive system dysfunction. Recycling is not widely available for polystyrene products. Most curbside collection services will not accept EPS (encapsulated poly styrene), as this material accounts for about 35 percent of US landfill material. The reason is its light weight (>90 percent air). While the technology for recycling polystyrene is available, the market for recycling is small (Hopewell, 2009).

Styrofoam Densifier, Australia

PS foam is collected through curbside or depot programmes. The material goes through a densifier where it is compacted into blocks. The plastic blocks are remanufactured into decorative mouldings and high-end picture frames. The global market for post-consumer PS foam is 1,20,000 tonnes per year.

India is one of the signatory countries to the International EPS recycling agreement. We have a good scope in India to recycle this form of plastic. Several studies have found that the bacteria Pseudomonas putida is able to convert polystyrene to a more biodegradable plastic. The process of polystyrene depolymerization – converting polystyrene back to its styrene monomer – is also gaining ground (Banerjee and Srivastava, 2014).

#7 – Other (BPA, Polycarbonate and LEXAN)

The #7 category was designed as a catch-all for polycarbonate (PC) and "other" plastics, so reuse and recycling protocols are not standardized within this category. Of primary concern with #7 plastics,

however, is the potential for chemical leaching into food or drink products packaged in polycarbonate containers made using BPA (Bisphenol A). BPA is a xenoestrogen, a known endocrine disruptor (Banerjee and Srivastava, 2014).

#7 plastics are used to make baby bottles, sippy cups, water cooler bottles and car parts. BPA is found in polycarbonate plastic food containers often marked on the bottom with the letters "PC" by the recycling label #7. Some polycarbonate water bottles are marketed as 'non-leaching' for minimizing plastic taste or odor, however there is still a possibility that trace amounts of BPA will migrate from these containers, particularly if used to heat liquids.

A new generation of compostable plastics, made from bio-based polymers like corn starch, is being developed to replace polycarbonates. These are also included in category #7, which can be confusing to the consumer. These compostable plastics have the initials "PLA" on the bottom near the recycling symbol. Some may also say "Compostable."

#7 plastics are not for reuse unless they have the PLA compostable coding. When possible, it is best to avoid #7 plastics, especially for children's food. Plastics with the recycling labels #1, #2 and #4 on the bottom are safer choices and do not contain BPA. PLA coded plastics should be thrown in the compost and not the recycle bin since PLA compostable plastics are not recyclable(Banerjee and Srivastava, 2014).

The plastics industry has conformed to regulations by applying the required codes to consumer products, but it is up to individuals to read and understand the codes. By understanding these simple classifications, we can best use plastics to our advantage while minimizing the health and disposal issues that may otherwise arise (Hopewell, 2009).

(Watch Film: Central Coast Recycling https://www.youtube.com/watch?v=HBuOa-8PGoc)

Wastepaper Recycling Plant, Aurangabad

(Watch film 7 MGM Aurangabad, Waste Paper recycling plant (Film in Marathi) Duration 19 min

https://www.youtube.com/watch?v=9-316A4g0eg)

This film demonstrates how Mahatma Gandhi Mission, Aurangabad uses all old journals, assignments, papers to recycle in-house completely. First the papers are shredded by a shredder. This is weighed. 5 Kilograms of shredded paper is weighed and soaked in reclaimed water from the water recycling plant for 10 minutes. Shredded cardboard needs 24 hours to soak. Rosin and Alum solutions are added. The chemicals are diluted in water. A chart explaining the volume of rosin and alum to be used is displayed. For 5 Kilograms of paper, 150 grams of rosin is needed to bond the paper and 300 grams of alum powder for removing the ink from the shreds. The end product is turned into files and screen-printed. Hydro-pulper of 120 l capacity is loaded with the shredded paper for 10 minutes. I Kilogram of soaked cotton pulp is added along with the two solutions – rosine and alum. The final paper pulp is put in a univat to make paper board. 10 sheets are prepared separated by cloth layers. A screw press removes excess water and allowed to air dry. A calendaring machine flattens the paper 5 sheets at a time. Fresh paper is ready to craft into new file folders.

3.5 Precautions while Recycling Paper

As many as 550 mills in India use waste paper as primary fibre source for paper, paperboard and newsprint production. This waste paper is sourced indigenously as well as through imports. The present recovery and utilisation of waste paper by paper mills in India is 3.0 million tonnes annually, which translates to a recovery of 27 per cent of the total paper and paperboard consumed, very low when compared to recovery rates in developed countries like Germany (73 per cent), Sweden (69 per cent), Japan (60 per cent), Western Europe (56 per cent), USA (49 per cent) and Italy (45 per cent).

For paper, the codes are 20-PAP for recyclable cardboard, 21-PAP for recyclable magazines, mail, catalogues, and other related paper products and 22 PAP is a general code for paper (Hopewell, 2009). If there is no code, the paper can still be sent for recycling. However, some places do not accept magazines and periodicals. Their coloured ink interferes with the recycling process(Banerjee and Srivastava, 2014).

Due to inadequate availability of indigenous waste paper, Indian mills rely heavily on imported waste paper to meet the raw material demand. The import bill, in fact, has increased significantly over the years. India imports around 4.0 million tonnes of waste paper annually which is about 57 per cent of its requirements. The solution is in harnessing the post consumer paper, or waste paper, at home, since it is the most important renewable raw material source for the paper industry and can contribute considerably towards reduction in its imports. Its recycling is also crucial from the environmental perspective, as systematic collection and recycling of waste paper can significantly reduce the generation of municipal solid wastes. According to some estimates, one tonne of recycled paper saves approximately 17 trees, 2.5 barrels of oil, 4100 Kilowatt hours of electricity, 4 cubic meters of landfill and 31,780 litres of water (Hopewell, 2009).

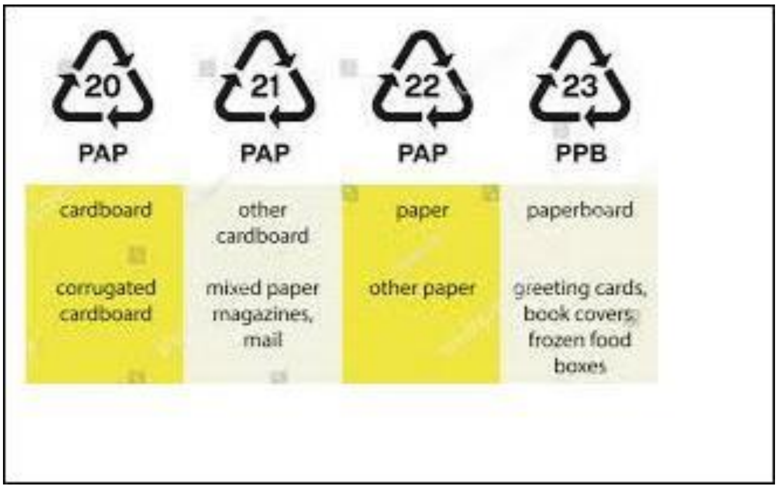


Fig. 3.12 International Symbols for Paper Segregation (Source: Hopewell, 2009).

There are several grades of paper that cannot be sent for recycling:

- Wax paper, plastic or foil-coated papers cannot be recycled, e.g. frozen food boxes, juice boxes, milk cartons.
- Soiled/ unclean paper: paper contaminated with food waste, oils, used tissues etc carry viruses, bacteria and moulds (fungus).
- Shredded paper: Shredding weakens the length of paper fibres. It is best to compost shredded paper along with nitrogen-rich decaying food to offset high nitrogen and add carbon.

Reuse

When the recyclables are simply broken or melted and shaped into new products, with and without recasting, it is called reusing. Plastics, glass, rubber tyres, etc can be reused. For example, plastics are melted to make synthetic marble with attractive patterns, tyres are shredded to make crumb rubble for roads (though this has been a cause of worry for environmentalists since the crumb rubber erodes from the road surface due to friction and escapes with rainwater runoff, thus causing water pollution), and glass is melted to form countertops, etc. Plastic roads have gained much popularity in India to tackle #7 plastics (Banerjee and Srivastava, 2014).

Case study: Farmers successfully applying Municipal Waste to Crops

Problem: Farmers across India realize that plants absorb only twenty percent of added Urea, while rest of the eighty percent is leached into soil, causing nitrate pollution in well water.

Solution: Kuilapalyam village in T.N. uses coir pith to do very low-cost of city waste composting under shady trees.

Method:

Villagers bring garbage from Pondicherry at the rate of Rs 20/- per cart-load and pile it into platforms (20’x20’x4’) under the tamarind-trees near their village huts. Only segregated “wet waste” without any plastic contamination can be used for this technology. This pile is covered with 6” of coir – pith purchased from Pondicherry at Rs 50 per cart-load. The coir pith acts as an insulating blanket that locks in heat, moisture and odour. It also keeps out flies and animals, hides the ugliness of heaps and protects compost from rain. Composting is accelerated by sprinkling the fresh garbage heaps in layers with water containing five percent fresh cowdung and dusting 5 Kilograms of Rock Phosphate per ton of garbage.

The temperature builds up very fast, reaching 70oC in 5-7 days. The high temperatures speed up the composting, kill weed seeds and kill germs that cause diseases like cholera, typhoid, hepatitis and worms. After a week, they turn the heap, placing the outer material in the centre of the new heap and the hot inner material on the outside of the new heap. Compost is ready in 4 weeks with 3-4 turnings. This heap is left undisturbed for several months until needed. By then, the rotten waste and the coir pith decompose completely and are applied to fields in the planting season.

Advantages:

1. Composting is a pollution-abatement technology. City compost acts like a sponge, absorbing urea for later use. So, 1 bag of urea used with compost is equivalent to 5 bags.
2. This compost makes the crop very drought-resistant as the coir-pith helps to retain water for long.
3. Compost use makes soil porous, so roots are stronger. This strengthens the plant’s natural resistance to pests and decay.
4. Farmers using compost find they need far less pesticides, saving input costs with less environmental pollution.
5. Fruit from compost-grown plants are larger, tastier, have better colour and shelf life and fetch better prices.
6. Compost use restores fertility to water-logged and saline soils. India has 22 million hectares of alkaline and saline barren soils awaiting rescue. Experiments at Kutch and by Bhoomi Sudhar Nigam of Uttar Pradesh have proved the benefits of using compost. Full yields are restored in 3 years to totally-barren soils. Soils deficient in micro-nutrient also benefit.

Case study: Farmers successfully applying Municipal Waste to Crops

Precautions

Since no sieving is done, the wet waste must be plastic-free. Soil which contains plastic bags cannot absorb rain-water well. Seeds cannot germinate well. Plastics make the soil less fertile every year.

Recommendations:

Encourage private composting efforts by:

Waste segregation at source. SJSRY schemes for collection of compostable waste and decentralised composting

- Free delivery of garbage to the composting spot
- Buy-back off-season compost for city gardens
- Encourage banks to finance storage sheds for finished compost at the composters' site
- Make co-marketing of city compost and chemical fertilizers compulsory. Creative solutions are needed for bulk storage, timely availability, affordability and ease of application.

How to Prepare Biodiesel from Waste Cooking Oils

Waste cooking oils are difficult to treat. They can slow down or completely stop the composting process. Tipping them down through drains causes grave water pollution and it is very expensive to clear blockages caused by fats and greases. Just one litre of cooking oil can pollute up to 1 million litres of drinking water.

A company in United Kingdom(UK) collects used Cooking Oil (UCO) from fish-frying industry, cafes, restaurants and food businesses and converts into biofuel, a low carbon alternative to diesel that lowers greenhouse gas emissions by over 70 percent

Indian Bioenergy is an Indian company located in Nandi Hills, Bengaluru, which collects waste cooking oil on a regular basis, on a scheduled basis at an agreed frequency, with a reminder. The company also supplies a barrel or container for storing waste oil, if needed. Used cooking oil is collected against a Waste Transfer Note which can be exchanged for biodiesel.

To know the details of how to make biodiesel, watch the following videos

- Biodiesel from Cooking oil- How To Make Biodiesel Using A Used Cooking Oil : Duration4 min. https://www.youtube.com/watch?v=qi1cqmvio5YHow to make biodiesel: Duration 9 min
- https://www.google.co.in/search?q=how+to+make+biodiesel+from+vegetable+oil+wast e&r lz=1C1CHZL_enIN815IN815&oq=how+to+make+biodiesel+from+cooking+oil&aqs=chro me. 4.69i59j0l5.8626j0j8&sourceid=chrome&ie=UTF-8#kpvalbx=1

Summary

Different organic matter is composted in different ways: locally, centrally, aerobically or anaerobically. Well composted waste becomes good soil conditioner and is capable of sequestering carbon. Poorly composted waste could cause health issues and aid in spreading seeds of invasive plant.

Plastics, paper, glass and metals can be recycled if segregated well. Those materials that cannot be recycled can sometimes be reused, such as for road-making.

Further Reading

Swachh Bharat Guidebook

https://swachhbharaturban.gov.in/writereaddata/Swachh_Bharat_Guidebook_v23.p df

To Do Activities

1. Begin with a small practical exercise of setting up a compost pit. It could be in the ground or in suitable containers. This project can be expanded as the course progresses.
2. Explain the Waste Management Hierarchy. Discuss in class what level they observe themselves and their neighbourhood. What steps would be ideal.
3. Classroom teaching of Aerobic, anaerobic composting, vermicomposting, pipe composting. Ask students to explore the Krishi Vikas Kendras and other NGOs/ businesses selling microbe mix for quick composting. Encourage them to experiment with their compost pit. Let them practice composting leaf litter, too.
4. Visit to any agency involved with composting of Municipal Solid Waste to observe open windrow composting, mechanical composting and the different steps involved in the composting business etc.
5. Watch videos of preparing biodiesel from waste cooking oil.
6. Run an experiment to prepare biodiesel, if possible. Source waste oil from the College Canteen
7. Make students interview one or two recyclers, or waste collectors. The student can report their findings in a class seminar.
8. Prepare a composting pit for leaf litter collected from your campus, modelled on “amritmatti’.
9. Set up a composting pipe and use it at the college for kitchen waste. What are the practical difficulties with the system? How can it be overcome?

10. Collect plastics from the campus. Segregate them as per categories. Take guidance from a plastic recycler/ scrap dealer. Understand the difficulties faced when the recycling codes are absent.
11. Create hand-made paper out of beverage cartons.
12. Make your own biogas plant https://www.instructables.com/id/Bio-gas-plant-using-kitchen-waste/
13. Make your own biodiesel with waste cooking oil.
14. Watch video of making plastic into petrol/ diesel

Discuss on what topics each student is interested in, scope out possibilities of career development, research or internship opportunities

Model Questions

1. Compare various methods of composting organic matter. Which method is most suitable for your lifestyle?
2. How is paper recycled?
3. Which are the types of plastics to be avoided?
4. Which is the best way to recycle old cooking oil?

Reference Book

• Swachh Bharat - Guidebookhttps://swachhbharaturban.gov.in/writereaddata/Swachh_Bharat_Guidebook_v23.p df

Films

1. Pipe Composting: Duration 3.2 min https://www.youtube.com/watch?v=JXOo313n88M
2. Biodiesel from Cooking oil- How To Make Biodiesel Using A Used Cooking Oil : Duration4 min. https://www.youtube.com/watch?v=qi1cqmvio5Y
3. How to make biodiesel: Duration 9 min https://www.google.co.in/search?q=how+to+make+biodiesel+from+vegetable+oil+waste&rlz=1C1C HZL_enIN815IN815&oq=how+to+make+biodiesel+from+cooking+oil&aqs=chrome.4.69i59j0l 5.8626j 0j8&sourceid=chrome & ie=UTF-8#kpvalbx=1
4. How Sweden turns its waste into gold: Duration 20 min: https://www.youtube.com/watch?v=14r7f9khK70
5. How to turn plastic bottles into clothes. Duration 5.30 min: https://www.youtube.com/watch?v=zyF9MxlcItw
6. Central Coast Recycling https://www.youtube.com/watch?v=HBuOa-8PGoc
7. MGM Aurangabad, Waste Paper recycling plant (Film in Marathi) Duration 19 minhttps://www.youtube.com/watch?v=9-316A4g0eg

Chapter 4- Trades of Waste

Introduction

The global waste trade is the international trade of waste between countries for further treatment, disposal, or recycling. Toxic or hazardous wastes are often exported from developed countries to developing countries, also known as countries of the Global South

Objectives

- To learn the concept of polluter pay principle, extended producer responsibility, and other sustainability issues
- To learn Producer Responsibility organizations, Carrying capacity and precautionary principle
- To understand reverse logistics and scarp trade

Structure

4.1 Life Cycle Analysis (Cradle-to-Grave Analysis)

4.2 Agricultural waste

4.3 Extended Producer Responsibility

4.4 Producer Responsibility Organization

4.5 Reverse logistics

4.1 Life Cycle Analysis (Cradle-to-Grave Analysis)

With waste reduction and reverse logistics, much of the wastage can be reduced. However, there is need for technological advancements that will improve products, making them environment friendly at every stage of their existence. This demands a rigorous life cycle analysis (Karapetyana, 2015).

Life-cycle assessment (LCA, also known as life-cycle analysis, eco-balance and cradle-to-grave analysis) is a technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance.

LCA is a technique to assess the environmental aspects and potential impacts associated with a product, process or service. This assessment is exceptionally useful as it shows the designer what areas are the most impactful during the product’s life cycle. LCA can also help to compare newly redesigned products with the original, acting as a benchmark to ensure the design changes are actually positive for the environment. LCA is therefore used in new product research and development, when environmental footprint is important to the future marketing or cost structure of a product (Karapetyana, 2015).

LCA is not an exact science, unless it is done by the manufacturer himself. A third party reviewer without access to all process details is bound to make certain assumptions. The Eco-Indicator method is a tool developed to help designers conduct a simplified LCA study.

Step 1. Gather all required information

Step 2. Analyse the product, identify areas that need improvement and which ones work well.

Step 3. Create alternative concepts which are more eco-friendly

Step 4. A single score (Eco-Indicator point) is generated for all the impacts of the product

Step 5. Improve the design

Step 6. Assess the new design to check if the impact is lower.

Methodology

1.Establish the purpose of the Eco-Indicator calculations. State the assumptions made.

2.Define the life-cycle.

3.Quantify the materials and processes. .

4.Complete the form.

5.Interpret and analyse the results

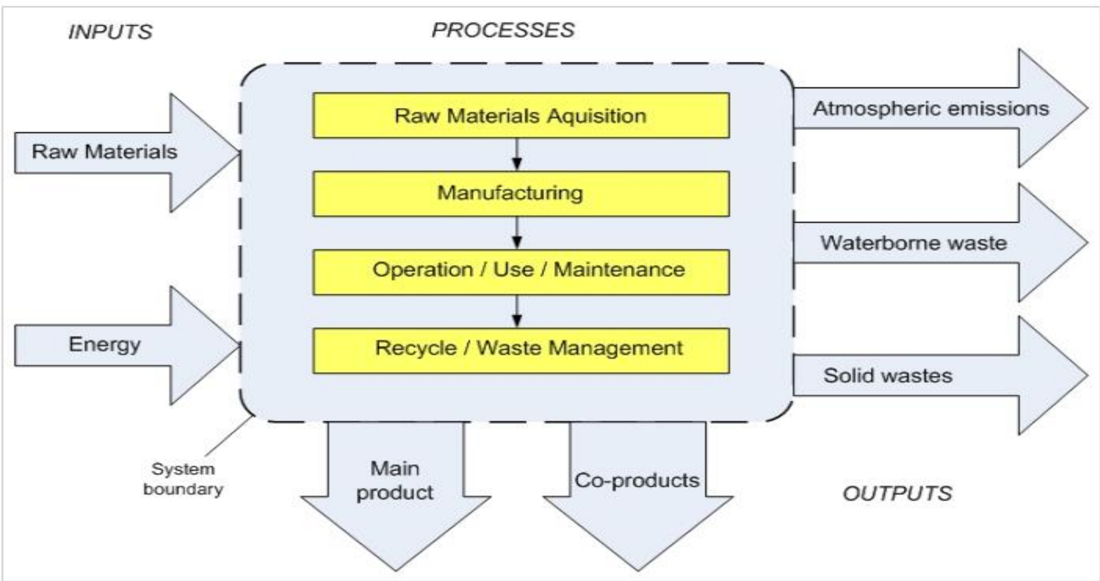


Fig. 4.1 Life Cycle Analysis (Source: Karapetyana, 2015)

4.2 Agricultural Waste

Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. They are the non-product outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficial use. Their composition will depend on the system and type of agricultural activities and they can be in the form of liquids, slurries, or solids. Agricultural waste otherwise called agro-waste is comprised of animal waste (manure, animal carcasses), food processing waste (only 20% of maize is canned and 80% is waste), crop waste (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, prunings) and hazardous and toxic agricultural waste (pesticides, insecticides and herbicides, etc). Estimates of agricultural waste arising are rare, but they are generally thought of as contributing a significant proportion of the total waste matter in the developed world. Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by-products. There is likely to be a significant increase in agricultural wastes globally if developing countries continue to intensify farming systems. It is estimated that about 998 million tonnes of agricultural waste is produced yearly. Organic wastes can amount up to 80 percent of the total solid wastes generated in any farm of which manure production can amount up to 5.27 kg/day/1000 kg live weight, on a wet weight basis (Upadhyay and Harshwardhan, 2017).

Sources of Agricultural Wastes

1. **Wastes from Cultivation Activities**

While tropical climate is favorable for growing crops, it also supports the generation and development of insects and weeds. This situation creates a high demand for pesticides in order to kill insects and protect against the spread of epidemic diseases; this need often lead to the abuse of pesticides by farmers. After using pesticides, most of the bottles and packages holding these pesticides are thrown into fields or ponds (Upadhyay and Harshwardhan, 2017).

2. **Wastes from Livestock**

Production Waste from livestock activities include solid waste such as manure and organic materials in the slaughterhouse; wastewater such as urine, cage wash water, wastewater from the bathing of animals and from maintaining sanitation in slaughterhouses; air pollutants such as H_2S and CH_4; and odors. The pollution caused by livestock production is therefore a serious problem since most of them are usually built around residential areas. Air pollution includes odors emanating from cages resulting from the digestion process of livestock wastes; the putrefaction process of organic matter in manure; animal urine, and/or from redundant foods. The intensity of the smell depends on animal density, ventilation, temperature, and humidity. The proportion of NH_3, H_2S, and CH_4 varies along with the stages of the digestion process and also depends on organic materials, the components of foods, microorganisms, and the status of the animals' health. This untreated and nonerasable waste source can generate greenhouse gases while also having negative effects on the fertility of the soil and causing water pollution. In livestock waste, water volume accounts for 75–95% of total volume, while the rest includes organic matter, inorganic matter, and many species of microorganisms and parasite eggs. Those germs and substances can spread diseases to humans and cause many negative effects on the environment (Upadhyay and Harshwardhan, 2017).

3. Waste from Aquaculture

The growth in aquaculture has led to an increase in the use of feeds for improved production. The amount of feed used in a system is the most important factor used in determining the quantity of waste generated. The wastes that result from the use of aquaculture feeds are discussed in this section of the report and it is a summary of the information provided by . One of the major wastes generated in aquaculture is metabolic waste which could be dissolved or suspended. In a properly managed farm, approximately 30% of the feed used will become solid waste. Feeding rates are dependent on the ambient temperature. Increase in temperature results in increased feeding which gives rise to increased generated waste. Water flow patterns in production units are important for waste management because a proper flow will minimize the fragmentation of fish faces and allow for rapid settling and concentration of the settleable solids. This can be critical because a high percentage of non-fragmented faces can be quickly captured which will greatly reduce the dissolved organic waste (Upadhyay and Harshwardhan, 2017).

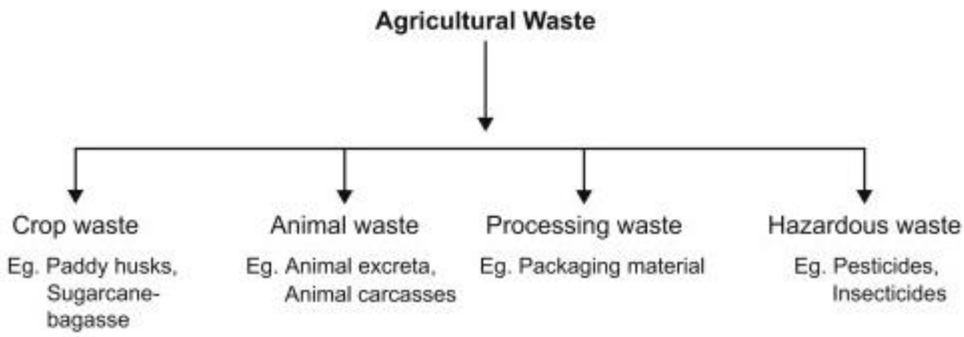


Fig. 4.2 Agricultural Waste (Upadhyay and Harshwardhan, 2017)

Anaerobic Digestion

Methane gas can be produced from agricultural wastes particularly manures. The gas is best suited for heating purposes as in broiler operation, water heating, grain drying, etc. The anaerobic digestion of agricultural waste to form methane-rich gas is a two step microbial fermentation. Initially, acid-forming bacteria break down the volatile solids to organic acids which are then utilized by methane-ogenic organisms to yield methane-rich gas (Figure1). The composition of the typical gas produced is: methane, 50-70%; CO2, 25-45%; N2, 0.5-3%; H2, 1-10% with traces of H2S; and the heating value of the gas is in the range of 18-25 MJ/m3[9]. Some of the major disadvantages of the digestion system are the high capital costs and the explosive properties of the methane gas. However, the advantages far outweigh the aforementioned disadvantages. Anaerobic digestion makes the treatment and disposal of large poultry, swine and diary waste feasible, minimizing the odor problem. It stabilizes the waste and the digestion sludge is relatively odour-free and yet retains the fertilizer value of the original waste. 3.3 Adsorbents in the Elimination of Heavy Metals Excessive release of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. Unlike organic pollutants, the majority of which are susceptible to biological degradation, heavy metal ions such as copper, cadmium, mercury, zinc, chromium and lead ions do not degrade into harmless end products. The presence of heavy metal ions is a major concern due to their toxicity to many life forms. Studies on the treatment of effluent bearing heavy metal have revealed adsorption to be a highly effective technique for the removal of heavy metal from waste stream and activated carbon has been widely used]. In recent years, agricultural wastes have proven to be a low-cost alternative for the treatment of effluents containing heavy metals through the adsorption process. The low cost agricultural waste such as sugarcane bagasse, rice husk, sawdust, coconut husk, oil palm shell, neem bark, etc., for the elimination of heavy metals from wastewater have been investigated by various researchers (Upadhyay and Harshwardhan, 2017).

Pyrolysis

In pyrolysis systems, agricultural waste is heated up to a temperature of 400-600°C in the absence of oxygen to vaporize a portion of the material, leaving a char behind. This is considered to be a higher technology procedure for the utilization of agricultural wastes. Others are hydro-gasification, and hydrolysis. They are used for the preparation of chemicals from agricultural waste as well as for energy recovery. Of particular interest to agriculture are the preparation of alcohols for fuel, ammonia for fertilizers, glucose for food and feed. Pyrolysis of agricultural waste yields oil, char and low heating value gas (Upadhyay and Harshwardhan, 2017).

Polluter Pays Principle (PPP)

In environmental law, the polluter pays principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment. It is regarded as a regional custom because of the strong support it has received in most Organisation for Economic Co-operation and Development (OECD) and European Union countries. It is a fundamental principle in US environmental law (Mahaseth, 2017).

The 'polluter pays' principle is the commonly accepted practice that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment. For instance, a factory that produces a potentially poisonous substance as a by-product of its activities is usually held responsible for its safe disposal. The polluter pays principle is part of a set of broader principles to guide sustainable development worldwide (formally known as the 1992 Rio Declaration) (Mahaseth, 2017). This principle underpins most of the regulation of pollution affecting land, water and air (Mahaseth, 2017).

India's Stand on Polluter's Responsibility

Polluter Pays is an important principle for environmental law and governance in India. The Supreme Court of India has laid down the rule of absolute liability which essentially states that a person would be wholly responsible for any mishap caused by their “hazardous or inherently dangerous” enterprise. Court noted that the polluter would need to pay for cleaning up the damage as well as compensate those harmed by the pollution. However, under the public interest litigation route, courts in India have often also held the government liable for failing to curb the pollution and have directed them to pay for the costs of environmental damage. Ultimately, in the National Green Tribunal Act 2010, it was stated that the NGT would decide cases based on the polluter pays principle (among others).

PPP has also been applied more specifically to emissions of greenhouse gases which cause climate change. In this regard, PPP is implemented through a ‘carbon price’. Many economists argue a carbon price should be global and uniform across countries and sectors so that polluters do not simply move operations to so-called 'pollution havens' – countries where a lack of environmental regulation allows them to continue to pollute without restrictions (Mahaseth, 2017).

A Precautionary Principle is also stated in the Rio Declaration, which stipulates that, where there are “threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.” In other words, when an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. To understand the importance of the Precautionary Principle, it is important to first understand the concept of assimilative capacity (Mahaseth, 2017).

Assimilative Capacity

Assimilative capacity refers to the ability of the environment or a portion of the environment (such as a stream, lake, air mass, or soil layer) to carry waste material without adverse effects on the environment or on users of its resources. The assimilative capacity is dependent upon physical characteristics of the air, water and soil and varies from location to location.

Pollution occurs only when the assimilative capacity is exceeded. The Polluter Pays Principle allows the use of economic instruments, tradable pollution rights and environmental standards assuming that the environment has a certain assimilative capacity to absorb waste materials without long-term damage. This idea is based on the fact that some wastes, such as naturally occurring organic wastes decompose and break down in the environment if they are present within limits.

This approach is highly dependent on the ability of scientists to assess the impact of pollutants on the environment and to determine a safe level that will not irreversibly or severely damage the environment (Mahaseth, 2017).

Application of the PPP in Waste Management

There is a wide variety of methods for the application of PPP in waste management, targeting different types of waste and waste producers. There is generally no right or wrong approach in applying PPP in waste management. An integrated waste management strategy will often require a combination of different measures. In any case, any single measure or combination of measures needs to be thoroughly evaluated before implementation, carefully weighing the costs of implementation against the expected benefits, and adapted to the circumstances of a particular country or region. In the following, different methods of applying the PPP in waste management are briefly presented. One can generally differentiate between economic instruments and legislative measures. While economic instruments seek to force changes in behaviour of waste producers through changes in the cost structure at some point in the product life cycle, legislative measures work through the restriction of waste management options legally available. For an overview of different instruments applied in different environmental domains (including waste management) in different countries of the world, refer to the "OECD/EEA database on instruments used for environmental policy and natural resources management" which is freely available in the internet. a) Waste tariffs/fees for waste collection/treatment/disposal: The most obvious (and common) economic instrument used to apply PPP are waste tariffs or fees charged upon different waste producers (i.e. households/consumers, commerce, industry), aimed at recovering the cost of building and operating the services and infrastructure required for collection, treatment and disposal of the waste they produce. When correctly applied, they also send signals to consumers to reduce the amount of waste produced. Tariffs and fees are applied in many countries to finance municipal solid waste management systems. In the case of residential (households) and smaller non-residential waste producers, waste tariffs and fees are paid in many different forms, but most commonly in form of a monthly flat-fee charge (per household or per person) or as a volume-based tariff (i.e. for receptacles or bags with fixed volumes and collected with defined periodicity). Another method is the payment of waste charges together with the property tax (i.e. calculated based on type and size of property). For large commercial and industrial producers of municipal waste there is generally a weight-based gate-fee, which has to be paid directly at the treatment or disposal facility. Some countries have introduced weight-based tariff systems also for residential and small nonresidential waste producers, which provide the best signal to reduce waste and therefore constitute the ideal application of the PPP. However, its application requires additional investment, operating and administrative cost, which is not always affordable. In many countries, separate tariffs and fees apply for the disposal of hazardous wastes produced by industry. This makes sense, as their management requires special collection, treatment, and disposal facilities. These may be paid directly at the treatment or disposal facility as a gate-fee or in advance, in the form of an advanced disposal fee. In addition to special tariffs/and fees, hazardous waste management systems often impose use and handling restrictions on hazardous waste producers through a series of legislative measures that seek to minimize the use of hazardous substances and the generation of wastes containing them. b) Environmental taxes: Other economic instruments are applied to discourage consumption of specific types of products, and thus reduce the arising of specific types of waste (i.e. product taxes), or to discourage specific types of waste disposal schemes (i.e. landfill tax). Usually, environmental taxes have the objective of raising revenue to support environmental programmes, which however must not necessarily be targeted at dealing with the specific type of waste from which the tax comes from. Product taxes are applied on the price of certain goods such as disposable or non-recyclable beverage containers, plastic tableware, plastic bags, disposable cameras, products containing hazardous substances, etc.). Raw material taxes are similar to product taxes but they are effective further upstream in the product lifecycle. They are applied on raw material used for the production of goods whose consumption is to be discouraged (i.e. raw material used to produce plastic liquid containers). Waste disposal or landfill taxes have been introduced in several EU countries as a means to discourage landfilling of waste and/or providing incentives for general waste prevention or recycling (Mahaseth, 2017).

4.3 Extended Producer Responsibility (EPR)

A concept closely related to the PPP is that of Extended Producer Responsibility (EPR). The OECD defines EPR as: "An environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. An EPR policy is characterised by:

(1) Shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities (and thus the public in general); and

(2) Provision of incentives to producers to take into account environmental considerations when designing their products.

While other policy instruments tend to target a single point in the chain, EPR seeks to integrate signals related to the environmental characteristics of products and production processes throughout the product chain." There are many variations in the implementation of EPR. The most common EPR schemes include: - Take-back schemes: impose a legal requirement on manufacturers, importers, and sellers to take back their products from end users at the end of the products' useful life - Deposit-refund schemes: require the collection of a monetary deposit on a product's packaging, usually beverage containers, at the point of sale. The deposit is refunded to the redeemer when the container is returned to an authorized redemption center. Non-recovered deposits may be used to finance waste collection and disposal facilities. Most current EPR schemes target packaging waste but also other types of wastes, such as batteries, electronic waste, end-of-life vehicles, vehicle tyres, and other consumer goods. The EPR concept provided the basis for the EU Directives regulating the (separate) management of Packaging Waste, WEEE, ELV, batteries, and other special wastes(Bhasker,et al. 2015).

Extended Producer Responsibility (EPR) is a policy approach, wherein, a producer is held responsible for the post-consumer stage of a product, typically for defined tasks of separate collection (e.g. for hazardous waste components), reuse (e.g. disposal-refund systems for bottles), recycling (e.g. for used cars) and / or storage and treatment (e.g. for batteries). EPR programs are commonly made mandatory through legislation, but can also be adopted voluntarily (i.e. retail take- back programs) (Bhasker,et al. 2015).

The advantages of EPR systems include

- Reduction in natural resource demands of packaging and product containers
- Create incentives for environmentally friendly product designs
- Reduce waste disposal costs for ULBs
- Provide a monetary incentive to the consumer to return the product or package
- Create infrastructure for collection and recycling of material

Extended Producer Responsibility (EPR) around key problem wastes like electronics, batteries, packaging and consumer durables (e.g. home appliances, electronics, home and office furniture) is essential for their appropriate disposal. Extended Producer Responsibility (EPR) policies are usually legislated at State and National levels (Bhasker,et al. 2015).

In India, the informal sector (kabadi system) is largely involved in collection of recyclables and material recovery. EPR initiatives which integrate and encourage informal sector participation in collection of recyclables from consumers benefit from the increased collection efficiency that this sector is able to achieve, which may then result in lower supply chain costs (collection costs) (Bhasker,et al. 2015).

Additionally, the National or State Government can promote initiatives which would encourage adoption of waste minimization oriented practices:

- Promotion of voluntary action: Encouraging business groups to reduce volumes of packaging, while maintaining the requisite strength.
- Authorizing local authorities to frame rules and local bye laws and enact local ordinances banning use and/or sale of certain types of products and packaging that cannot be reused, repaired, recycled, or composted. National/State level legal frame work and policy should also mirror such ordinances, to better enable local authorities to enforce such ordinances, laws and rules.
- Develop eco-labeling standards based on potential for waste reduction due to product packaging and potential for recycling/ reuse
- Promote development of eco-industrial parks, which are industrial areas where in material and resource exchange synergies, are established between businesses and industries. Such parks might operate facilities for recycling and product reuse processes.

Typical EPR Tools

Deposit-Refund Systems (also known as beverage container deposit legislation and bottle bills): Producers charge the consumers an additional disposal fee, which is refunded upon receiving the used container. In the beverage industry, used glass bottles and aluminium cans are collected by the seller from the user and the deposit is refunded, for e.g. reusable soft drink glass bottles and large sized mineral water containers. Lead acid batteries are also taken back through the deposit-refund system, by manufacturers. Example: In 2003, Germany introduced a mandatory Deposit-Refund System for certain one-way beverage packaging, which is defined as ecologically disadvantageous. The main goal is to discourage this packing in the market.

Quotas: Government authorities stipulate that a certain percentage of product content/ products/packaging material should be from recycled material. Example: Germany has set a requirement in its previous packaging ordinance that 72% of beer and soft drink containers be refillable. If the quota is not achieved, a mandatory deposit system will enter into force. Through an amendment of the ordinance, most beverage one-way containers are subject to the mandatory deposit system.

Product Charges: Product charges influence the choice of materials used. An eco-tax levied on PVC in Belgium increased the cost of the product and reduced consumption of this polymer.

Collection Systems: Producer and/ or the retail trade can be made responsible for taking back packages and used products such as batteries and CFL. Example: Germany adopted in 1991 the first Packaging Ordinance, which makes industry responsible for collecting packages.

Product Bans: The threat of product bans motivates producers to phase out undesirable materials, to design for recyclability and ensure high rates of reuse or recycling. Example: In Sweden, the voluntary deposit system for aluminium cans results in achieving the government mandated recycling rate. The driver behind the deposit system is the potential for a 'can ban' if the rates fall below the recycling rate set by government.

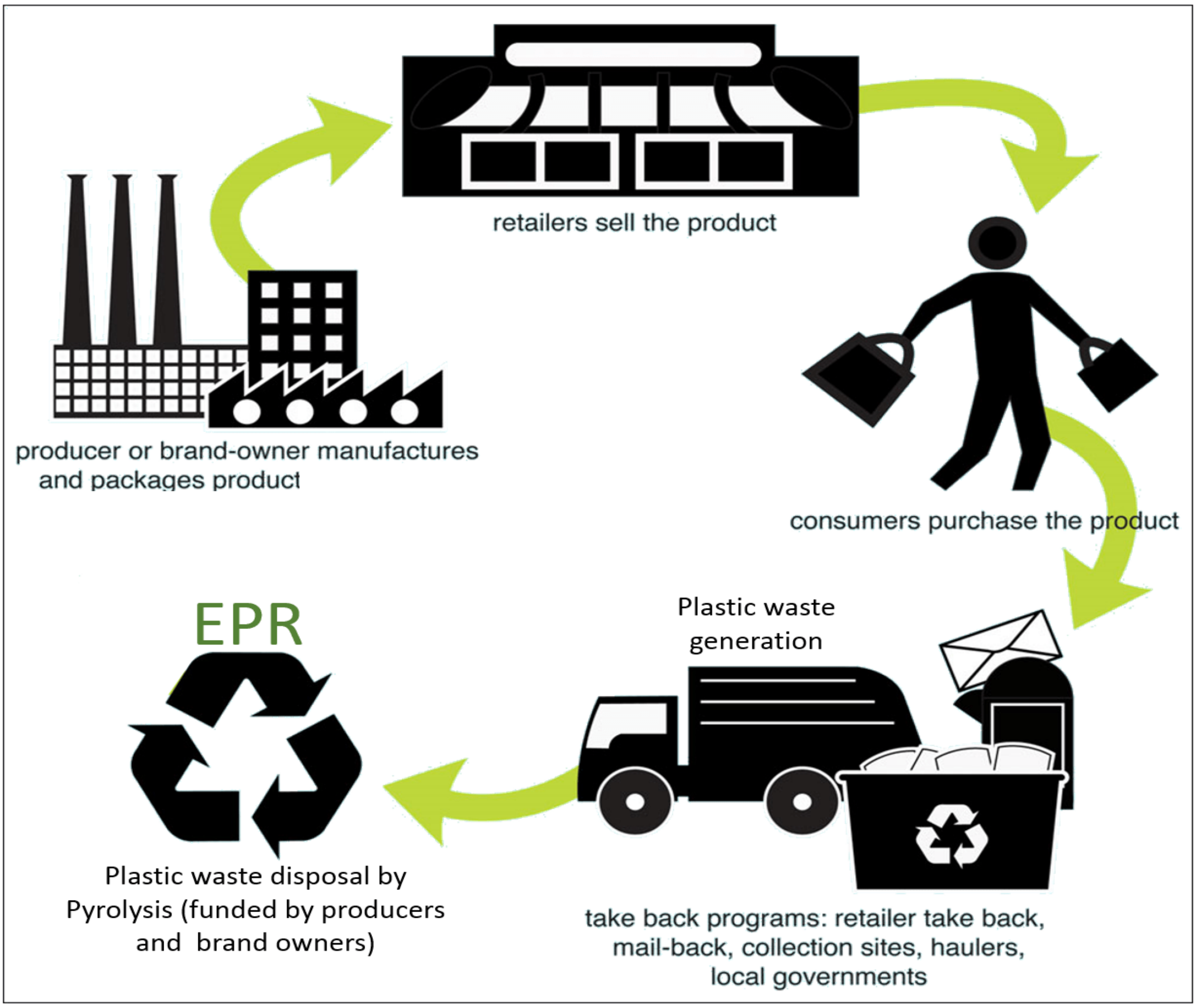


Fig. 4.3 Extended Producer Responsibility (EPR)

4.4 Producer Responsibility Organizations (PRO)

Companies in India have now started taking help of third party organizations to help them with their EPR. The cost of reverse logistics and compliance are high for an individual producer. It is also time and energy intensive. Producer Responsibility Organisation (PRO) take back waste from open market, recycle or process, and file compliance on behalf of the producer. The producers only need to support the process financially (Mayers, 2013).

This creates an opportunity for PROs to work with multiple producers.

Manufacturers pay service fee to PROs for enabling EPR compliance. The fee consists of:

1. Cost of reverse logistics
2. Cost of compliance

Initially PROs were tried only for e-waste.

PROs source waste from self-owned collection centres through the informal sector. Additionally, they also operate through franchisee-driven sourcing centres, which reduce transaction costs. In general, the obligation to recycle is transferred to a certified recycler. In few instances, these recyclers also operate as PROs by instituting their own collection channels.

Numerous Producer Responsibility Organisations (PROs) are now coming into the picture. CPCB has started registering PROs for plastic waste management**.** Companies too are warming up to the idea of PROs to deal with plastic waste**.** PepsiCo India committed to collecting and recycling PET plastic waste generated in Maharashtra. It partnered with Gem Enviro (PRO) to set up infrastructure for collection and recycling. The PET bottles would be recycled to manufacture thermal wear, furnishing fabrics and carpets.PET waste will be sourced through developed network of scrap dealers and contractors, who, in turn, work through informal ragpickers. Gem Enviro associated with Ganesha Ecosphere Ltd (GESL) as the collection and recycling partner. GESL sources raw material through a pan-India network of more than 20 collection centres. PET waste at collection centres are further sent for processing. This established network enables collection of about 225 tonnes of PET waste daily(Mayers, 2013).

Waste Collection Model of PROs

Saahas Zero Waste (SZW), is another name in the field of reverse logistics, collecting plastics through extensive network of informal sector in Bengaluru, Gurugram, Chennai, Hyderabad, Surat, Bellary and Hubli.SZW has a strong collection model involving scrap dealers and informal sector of waste collectors who ensure collection of large quantity of tetra paks. Material recovery facilities (MRF) are the secondary aggregation and segregation point. Secondary segregation of paper, glass, metal and plastic is done at the MRF. Plastic is further segregated into 16 categories to increase sale value. SZW acts only as a collection partner and forwards the materials to Tetra Pak on reaching threshold (holding capacity of MRF). This model is a perfect example of strengthening existing value chain to ensure efficient sourcing of waste (Mayers, 2013).

Waste Venture, a PRO operating from Hyderabad offers PRO solutions for a leading FMCG. The collection chain is driven by web app and on-call demand-based collection from residential and commercial establishments. This is further supported by nearly 30,000 informal waste collectors associated with the PRO. Waste Ventures created a database of these waste pickers, provided social identity, infrastructure and training on safe and hygienic way of handling waste. This ensured supply of quality raw material from these informal waste collectors at lower rates compared to an aggregator.

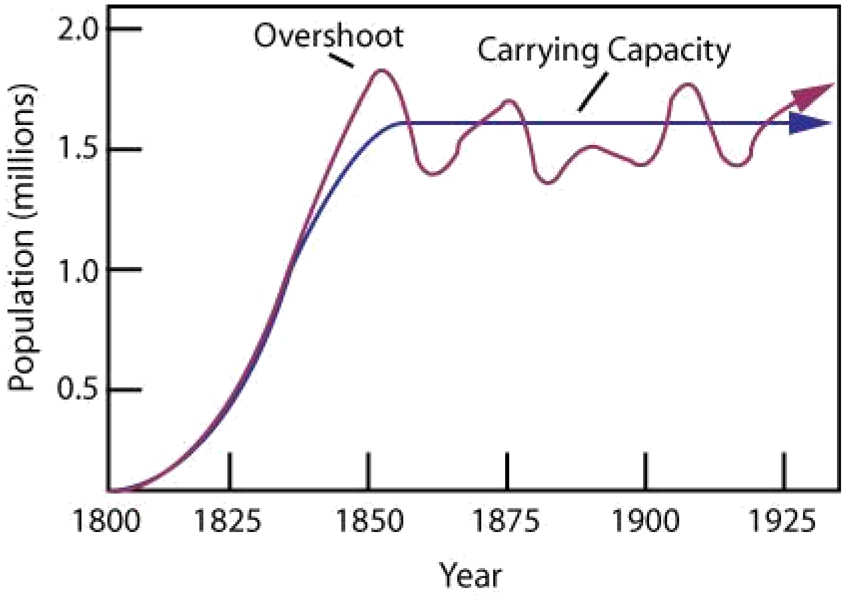


Fig. 4.4 Carrying Capacity for a Particular Species (Humans in this Example)
Source:http://www.algebralab.org/practice/practice.aspx?file=Reading_CarryingCapacity.xml

Challenges for the PRO

1. PROs experience great challenges on the ground due to low level of source segregation. To make PROs effective, segregation at source needs to happen. Waste pickers collect high-value waste rather than low-value plastic with high volume. Indiscriminate scattering of products, some of which are not produced by a known brand, makes it even more challenging.

2. Infrastructure deficit: The manufacturers are process-oriented entities with a formal structure. The Plastic Waste Management Rules specify that the manufacturer is to develop a mechanism to collect back the plastic waste in collaboration with the local bodies. The readiness of ULB to work in tandem with the manufacturers, considering the grassroots-level challenges and existing infrastructure deficit is not completely certain. A forced collaboration might not be required.

3. Monitoring and reporting structure: A strong monitoring and reporting structure is needed for both PROs and recyclers. A real-time assessment and mapping of supply by producer and state-wise consumption is required to determine the realistic and accountable EPR. Guidelines for registration as PRO and the roles of each stakeholder must be clearly drafted and enforced by the legislature.

4. PRO has to invest in a collection channel that would ensure continuous flow of high-quality source material. The optimal solution is to invest in the existing channel. The knowledge persisting in the informal sector is enormous and needs to be captured. Karo Sambhav, a Gurugram-based PRO, has created a strong network of informal sector. With this, the PROs can address the need for cost-effective collection of waste and safe disposal.

Carrying Capacity

Carrying capacity in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment. Carrying capacity may be seen as an equilibrium or balance. Overburdening the environment with overpopulation or excessive exploitation of resources makes the environment lose its balance, thereby causing widespread destruction until a new balance is achieved (Tian, 2013).

Carrying capacity is not a fixed number. Estimates put Earth's carrying capacity at anywhere between 2 billion and 40 billion people. At the present rate of consumption, 10 billion people are the uppermost population limit where food is concerned. There are currently 7 billion people alive on Earth today. The carrying capacity changes according to a wide range of factors determined by our lifestyle. To sustain life it is important to keep in mind the carrying capacity of land. Many interventions have been done in the past to improve the carrying capacity of land. For instance, the Green Revolution in India brought with it high yielding crops and widespread use of pesticides, fertilizers and diversion of water for irrigating croplands. A few decades down the line, we are facing the repercussions of the Green Revolution with soil salinity due to over irrigation, rendering good farmlands barren. The agricultural runoff has caused mass contamination of soils and water, including groundwater. The quality of food available is rich in carbohydrates, high in yield, but dismally low in proteins because fertilizers only replenish macro nutrients like nitrogen, phosphorus and potassium but not the micronutrients which are essential for crop growth (Tian, 2013).Carrying capacity of land depends on soil health. The health of soil is determined by the following characteristics:

Table 4.1 Characteristics of Healthy Soil

Physical	Chemical	Biological
Aggregate and Structure	pH	Roots
Porosity	Soluble salts	Microorganisms
Compaction	Nutrient Holding Capacity	Microfauna
Surface Sealing	Sodium	Macrofauna
Water Availability	Nutrient Availability	Biological Activity
Water Movement	Toxins	Organic Matter

Proper waste management by the vast majority of citizens can help improve the carrying capacity of the environment in the following ways:

1. Wet (biodegradable) wastes can provide a solution to the food problem of India. By applying compost as a soil conditioner over vast tracts of barren land, an attempt can be made to improve the carrying capacity of the land.

2. Preventing the entry of toxic or potentially toxic material into landfills by moving them for recycling or reuse.

3. Reducing the requirement of resources- metals, petroleum oils, will bring down the requirement for mining.

4. Proper waste management prevent air pollution to a large extent.

5. Responsible behaviour of producers towards environment and communities can bring about change in products and technologies that are less harmful to the environment.

6. There are a few more important game changers that could bring us back from the brink of total environmental collapse. The important thing to remember is that the Earth has enough for every man's needs, but not for every man's greed. The degradation of Earth's carrying capacity for humans is associated with two integrated factors: (1) overpopulation and (2) the intensity of resource use and pollution. It is in our hands to control these two factors, thereby ensuring continued life on this planet (Tian, 2013).

Precautionary Principle:

The precautionary principle (or precautionary approach) generally defines actions on issues considered to be uncertain, for instance applied in assessing risk management.The principle is used by policy makers to justify discretionary decisions in situations where there is the possibility of harm from making a certain decision (e.g. taking a particular course of action) when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result (Hayes, 2005).

Precautionary Principle is nothing but rephrasing of the adage, 'to be on the safe side' describes Often? we are not sure if our actions will have a negative impact. Keeping a reactive 'wait-and-see' approach can cause widespread environmental damage at times. Therefore, the principle is used by policy makers to justify their discretionary decisions in situations where there is the possibility of harm, especially when extensive scientific knowledge on the matter is lacking (Hayes, 2005).

Article 3 of the UNFCCC contained the precautionary principle and made it one of the most popular legal concepts in international environmental law today. The Precautionary Principle is applied where scientific understanding of possible risks is yet incomplete, such as the risks of nano technology, genetically modified organisms and systemic insecticides. It is imposed to protect the human rights of those affected (Hayes, 2005).

Guidelines in environmental decision making involve four central components of the precautionary principle:

- Taking preventive action in the face of uncertainty;
- Shifting the burden of proof to the proponents of an activity;
- Exploring a wide range of alternatives to possibly harmful actions; and
- Increasing public participation in decision making.

4.5 Reverse Logistics

Reverse logistics is for all operations related to the reuse of products and materials. It is "the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics (Huscroft, 2013).

The reverse logistics process includes the management and the sale of surplus as well as returned equipment and machines from the hardware leasing business. Normally, logistics deal with events that bring the product towards the customer. In the case of reverse logistics, the resource goes at least one step back in the supply chain. For instance, goods move from the customer to the distributor or to the manufacturer.

When a manufacturer's product normally moves through the supply chain network, it is to reach the distributor or customer. Any process or management after the delivery of the product involves reverse logistics. If the product is defective, the customer would return the product. The manufacturing firm would then have to organise shipping of the defective product, testing the product, dismantling, repairing, recycling or disposing the product. The product would travel in reverse through the supply chain network in order to retain any use from the defective product. The logistics for such matters is reverse logistics (Huscroft, 2013).

Reverse logistics is the set of activities that is conducted after the sale of a product to recapture value and end the product's lifecycle. It typically involves returning a product to the manufacturer or distributor or forwarding it on for servicing, refurbishment or recycling. Reverse logistics is sometimes called aftermarket supply chain, aftermarket logistics or retrogistics (Huscroft, 2013).

A well-managed reverse logistics program can result in

- Significant cost savings in procurement- collected material can be reused or added to the raw material
- Responsible disposal- this can significantly reduce carbon footprint, reducing materials going to landfills, ensuring safe disposal (in case of hazardous wastes, like batteries)
- Inventory holding and
- Transportation.

The aftermarket processes that a product can undergo in reverse logistics are numerous and include

- Remanufacturing - rebuilding the product with reused, repaired or new parts
- Refurbishment - resale of a returned product that has been repaired or verified to be in good condition
- Servicing - a broad category that includes customer service, field service and product returns, such as issuance of return merchandise authorizations
- Returns management

- Recycling and waste management
- Warranty management
- Warehouse management

Like other supply chain management (SCM) processes, reverse logistics can be made more efficient and profitable with better planning, management and execution, and is a key component of service lifecycle management (SLM). Reverse logistics can have a significant impact on a company's bottom line, in good and bad ways. For example, generous return policies can encourage distributors and retailers to order more stock than they expect to sell, which can increase inventory costs for manufacturers. Proper disposal of products can minimize penalties from noncompliance with environmental regulations.

The same SCM and e-commerce technologies involved in moving products to consumers (known as forward logistics) are used in reverse logistics, including barcodes and scanners used to track returns, materials handling systems in warehouses and Electronic Data Interchange (EDI) for transmitting documents between supply chain providers. SCM and ERP software vendors were initially slow to support reverse logistics, according to some experts, but most sellers now include some reverse logistics features in their suites. A number of niche vendors specialize in it. Third-party logistics providers (3PLs) also offer reverse logistics services (Huscroft, 2013).

Reverse logistics is a process whereby companies can become more environmentally efficient through recycling, reusing, and reducing the amount of materials used. A more holistic view of reverse logistics includes reduction of materials in the forward system in such a way that fewer materials flow back, reuse of materials is possible, and recycling is facilitated.

The measures aimed at reducing waste begin in the product design phase and incorporate the entire product life cycle, including transportation and final disposal. This will allow minimizing the waste downstream and allowing the product to go backward in the chain for possible re-manufacturer, reuse, recycling, or resell for secondary market.

Reverse Logistics vs Waste Management

Reverse logistics differs from waste management in that it focuses on the addition of value to a product to be recovered. On the other hand, waste management involves mainly the collection and treatment of the waste products that have got no new use.

A reverse supply chain is the network of activities involved in the reuse, recycling, and final disposal of products and their associated components and materials. The public is only concerned with the aftermath environmental impacts of the products at the end-of-use life.

Life Cycle Assessment (LCA) is an important tool in reverse logistics and involves assessing alternative materials and component concepts from the start of the development process and throughout the entire product life cycle, from the retrieval of raw materials through the utilization phase to recovery.

Worldwide Scenario

Waste management legislation in Europe is strong where firms are directed to address recovery and disposal of end-of-life products in an environmentally sound manner. As far as United States is concerned, economic factors focused on resource recovery value have been the main motivating factor.

On the other hand, reverse logistics in emerging economies is in early stages and depends heavily on third-party provider due to shortage of legislation, awareness, and infrastructure. Professional collection, sortingand transportation of end-of-life products are much needed in emerging markets such as Middle East.

In the developing world, reverse logistics work is characterized with low value addition due to the low reprocessing involved for example from recycled electronics, paper, automobiles, scrap, plastics and food waste. Unfortunately reverse logistics has not received the desired attention in developing countries and is generally carried out by the unorganized sector for recyclables like paper, plastics and metal.

Brazilian National Solid Waste Policy

In 2010, Brazil finalized its National Solid Waste Policy, a law that aims to decrease the total volume of waste produced nationally and increase the sustainability of solid waste management from the local level to the national level. Public, domestic, industrial, mining, forestry, transportation, construction, and healthcare waste are all covered by this policy, and much of the responsibility for paying for or providing management of waste falls to its producers.

The law outlines a variety of options for producers to work together within their sectors, with reverse logistics service providers, and with municipal and state governments to manage waste flows and to recapture, recycle, and ultimately dispose of these materials.

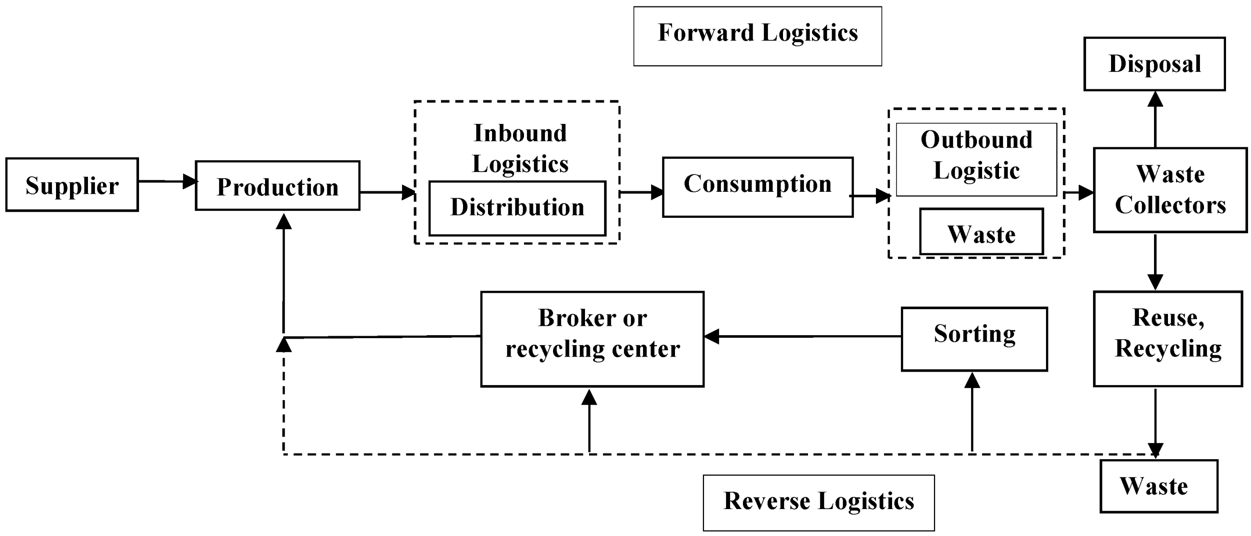


Fig. 4.5 Reverse logistic in waste management (Source: Kinobe et al. 2012)

Scrap Trade

The scrap market has become increasingly global in nature in recent decades. Figures from the United Nations Comtrade Database show that in 2015 alone, exports of all scrap commodities from reporting countries approached 180 million metric tons valued at more than $86 billion. While the United States is the largest exporter of recycled commodities in the world and China is the world's dominant consumer of commodities (including scrap), the scrap marketplace is far from bilateral, stretching to virtually every corner of the globe(Bosi, 2013).

The free and fair trade of scrap commodities provides tremendous economic and environmental benefits stemming not only from scrap's attractiveness as a low-cost raw material input for manufacturers, but also due to the energy savings, reduced depletion of natural resources, and reduction of material sent to landfills associated with scrap recycling. Maintaining open markets for scrap is vital to ensuring that recycling's economic and environmental benefits are fully realized (Bosi, 2013).

The tables below illustrate the flow of recyclables across the globe by major scrap commodity and importing/exporting economies, as well as the total amount of scrap traded globally:

Disposal of Used Drugs

Bio-medical waste management is a specialized subject. However, there is one stream of biomedical waste that recurs in household waste and mixes with municipal solid waste, ultimately entering water bodies or landfills. This is unused and outdated medicines. There are a wide range of pharmaceutical drugs (chemicals) being used which have a hazardous effect on the environment.

There exists no post-market survey of the quantum of unused drugs. Nonetheless, there is an urgent need for constructive disposal of these chemicals, especially antibiotics which are the leading cause of drug-resistance in patients.

The Kerala State Drugs Control Department in alliance with the all Kerala Chemists and Druggists Association has recently launched an awareness programme under the Suchitwa Mission (Local Self Government Department, Govt of Kerala) wherein the public will be directed to deposit expired and unused drugs at kiosks. The medicines will be collected and moved to a pharmaceutical waste treatment plant (Ramky) in Mangalore. This is a good example of how the Precautionary Principle can work in India.

Waste Management is a common responsibility of the produces, consumers and the governments. To implement, it requires stringent laws in place. Policies of Extended Producer Responsibility, Polluter Pays and Precautionary Principle are the three most prominent mechanisms to enforce waste management. Pollution is not limited to its source, but spreads across borders and ecosystems. We explored the world scenario of scrap trade, which is a boon for economies and ecology, provided stringent norms are applied to prevent pollution and health hazards. Consequently, many South East Asian countries are reluctant to bear the burden of the deleterious effects of this trade. The assimilative capacity of the environment and also the carrying capacity of the ecosystem require a proper understanding. With heavy pollution affecting almost the entire globe, it is time for us to practice bioremediation to clean up persistent pollutants, practice zero-discharge policies and give a chance to nature to revive.

To Do Activities

1. Discussion regarding who is responsible for waste- 5 minutes.
2. Explain Life Cycle Analysis (Cradle-to-Grave Analysis) applied to 2 products.
3. Collect soil samples. Using microbiological techniques, isolate different soil bacterial colonies.
4. Explain scrap trade, its financial implications and health implications.
5. Explain the precautionary principle to the class. Ask students to identify a few areas where the Precautionary Principle can be applied in real-life scenarios.
6. Discuss on what topics each student is interested in, scope out possibilities of career development, research or internship opportunities.

Model Questions

1. What is the purpose of Polluter Pays Principle?

2. Does the assimilative capacity of any part of the environment determine how much pollution is permissible? Explain.

3. What is precautionary principle?

4. What are the ways in which a polluter can take responsibility for his actions?

Video Film

1. Resource Efficient Economy: Managing Natural Resources: Making more with less,

Duration: 3.45 min https://www.youtube.com/watch?v=ZERrpF wETgs

Chapter 5- Case Studies

Introduction

The management of solid waste has become a major cause of concern over the past few years in both developed and developing countries. With rapid increase of population, urbanization and industrialization, there has been a marked rise in living conditions of people and this had lead to the generation of varied types of solid waste that needs to be effectively managed. For the sustainable development of any nation proper management of solid waste is very essential. Quantity estimation and characteristics of Municipal Solid Waste and its forecasting over the planning period is the key to its successful management plan. Given the existing scenario, the quantum of solid waste generated especially is set to rise in major cities due to more rapid growth of population further exacerbating the issue. This will require more focus on devising appropriate and effective mechanisms for handling such huge and excessive volumes of municipal solid waste management as improper management can lead to health and environmental hazards. In India, Municipal solid waste management is one of the most neglected areas of urban development even though a substantial portion of the municipality budget is attributed for this purpose.

Objectives

- To understand how the scrap trade and the informal recycling sector manage a large chunk of the recycling business while endangering lives
- To learn initiatives taken by firms and governments to do 3 R

Structure

5.1 International Trade of Waste

5.2 Initiatives taken by firms & government to do 3R

5.3 Initiatives related to waste management in India

5.4 Case studies in municipalities

5.1 International Trade of Waste

The global waste trade is the international trade of waste between countries for further treatment, disposal, or recycling. Toxic or hazardous wastes are often exported from developed countries to developing countries, also known as countries of the Global South. Therefore, the burden of the toxicity of wastes from Western countries falls predominantly onto developing countries in Africa, Asia, and Latin America. The World Bank Report What a Waste: A Global Review of Solid Waste Management, describes the amount of solid waste produced in a given country. Specifically, countries which produce more solid waste are more economically developed and more industrialized. The report explains that "generally, the higher the economic development and rate of urbanization, the greater the amount of solid waste produced. "Therefore, countries in the Global North, which are more economically developed and urbanized, produce more solid waste than Global South countries.

Current international trade flows of waste follow a pattern of waste being produced in the Global North and being exported to and disposed of in the Global South. Multiple factors affect which countries produce waste and at what magnitude, including geographic location, degree of industrialization, and level of integration into the global economy (Kellenberg, 2015).

Numerous scholars and researchers have linked the sharp increase in waste trading and the negative impacts of waste trading to the prevalence of neoliberal economic policy. With the major economic transition towards neoliberal economic policy in the 1980s, the shift towards "free-market" policy has facilitated the sharp increase in the global waste trade.

Given this economic platform of privatization, neoliberalism is based on expanding free-trade agreements and establishing open-borders to international trade markets. Trade liberalization, a neoliberal economic policy in which trade is completely deregulated, leaving no tariffs, quotas, or other restrictions on international trade, is designed to further developing countries' economies and integrate them into the global economy. Critics claim that although free-market trade liberalization was designed to allow any country the opportunity to reach economic success, the consequences of these policies have been devastating for Global South countries, essentially crippling their economies in a servitude to the Global North. Even supporters such as the International Monetary Fund, "progress of integration has been uneven in recent decade''(Kellenberg, 2015).

Specifically, developing countries have been targeted by trade liberalization policies to import waste as a means of economic expansion. The guiding neoliberal economic policy argues that the way to be integrated into the global economy is to participate in trade liberalization and exchange in international trade markets. Their claim is that smaller countries, with less infrastructure, less wealth, and less manufacturing ability, should take in hazardous wastes as a way to increase profits and stimulate their economies (Kellenberg, 2015).

Toxic Colonialism

Toxic colonialism, defined as the process by which "underdeveloped states are used as inexpensive alternatives for the export or disposal of hazardous waste pollution by developed states," is the core critique against the global waste trade. Toxic colonialism represents the neocolonial policy which continues to maintain global inequality today through unfair trade systems. Toxic colonialism uses the term colonialism because "the characteristics of colonialism, involving economic dependence, exploitation of labour, and cultural inequality are intimately associated within the new realm of toxic waste colonialism."

Electronic Waste

Electronic waste, also known as e-waste, refers to discarded electrical or electronic devices. A rapidly growing surplus of electronic waste around the world has resulted from quickly evolving technological advances, changes in media (tapes, software, MP3), falling prices, and planned obsolescence. An estimated 50 million tons of e-waste are produced each year, the majority of which comes from the United States and Europe. Most of this electronic waste is shipped to developing countries in Asia and Africa to be processed and recycled (Municipal solid waste management manual, Govt of India, 2014).

Various studies have investigated the environmental and health effects of this e-waste upon the people who live and work around electronic waste dumps. Heavy metals, toxins, and chemicals leak from these discarded products into surrounding waterways and groundwater, poisoning the local people. People who work in these dumps, local children searching for items to sell, and people living in the surrounding communities are all exposed to these deadly toxins (Municipal solid waste management manual, Govt. of India, 2014).

One city suffering from the negative results of the hazardous waste trade is Guiyu, China, which has been called the electronic waste dump of the world. It may be the world's largest e-waste dump, with workers dismantling over 1.5 million pounds of junked computers, cell phones and other electronic devices per year (Municipal solid waste management manual, Govt. of India, 2014).

Incinerator Ash

Incinerator ash is the ash produced when incinerators burn waste in order to dispose of it. Incineration has many polluting effects which include the release of various hazardous gases, heavy metals, and sulfur dioxide.

Khian Sea Incident

An example of incinerator ash being dumped onto the Global South from the Global North in an unjust trade exchange is the Khian Sea waste disposal incident. Carrying 14,000 tons of ash from an incinerator in Philadelphia, the cargo ship, Khian Sea, was to dispose of its waste. However, upon being rejected by The Dominican Republic, Panama, Honduras, Bermuda, Guinea Bissau, and the Dutch Antilles, the crew finally dumped a portion of the ash near Haiti. After changing the name of the ship twice to try and conceal the original identity, Senegal, Morocco, Yemen, Sri Lanka, and Singapore still banned the ship’s entry. Upon consistent rejections, the ash is believed to have been disposed of in the Atlantic and Indian Oceans. Following this disaster of handling hazardous waste, the Haitian government banned all waste imports leading a movement to recognize all of the disastrous consequences of this global waste trade. Based on the Khian Sea waste disposal incident and similar events, the Basel Convention was written to resist what is known to developing countries as ‘toxic colonialism.’ It was open for signature in March 1989 and went into effect in May 1992. The U.S. has signed the treaty, but has yet to ratify it.

Chemical Waste

Chemical waste is the excess and unusable waste from hazardous chemicals, mainly produced by large factories. It is extremely difficult and costly to dispose of. It poses many problems and health risks upon exposure, and must be carefully treated in toxic waste processing facilities (Municipal solid waste management manual, Govt. of India, 2014).

Impacts of the global waste trade

The global waste trade has had negative effects for many people, particularly in poorer, developing nations. These countries often do not have safe recycling processes or facilities, and people process the toxic waste with their bare hands. Hazardous wastes are often not properly disposed of or treated, leading to poisoning of the surrounding environment and resulting in illness and death in people and animals. Many people have experienced illnesses or death due to the unsafe way these hazardous wastes are handled.

Effects upon the Environment

The hazardous waste trade has disastrous effects upon the environment and natural ecosystems. Various studies explore how the concentrations of persistent organic pollutants have poisoned the areas surrounding the dump sites, killing numerous birds, fish, and other wildlife. There are heavy metal chemical concentrations in the air, water, soil, and sediment in and around these toxic dump areas, and the concentration levels of heavy metals in these areas are extremely high and toxic(Municipal solid waste management manual, Govt. of India, 2014).

Implications for Human Health

The hazardous waste trade has serious damaging effects upon the health of humans. People living in developing countries may be more vulnerable to the dangerous effects of the hazardous waste trade, and are particularly at risk from developing health problems. The methods of disposal of these toxic wastes in developing countries expose the general population (including future generations) to the highly toxic chemicals. These toxic wastes are often disposed of in open landfills, burned in incinerators, or in other dangerous processes. Workers wear little to no protective gear when processing these toxic chemicals, and are exposed to these toxins through direct contact, inhalation, contact with soil and dust, as well as oral intake of contaminated locally produced food and drinking water. Health problems resulting from these hazardous wastes affect humans by causing cancers, diabetes, alterations in neurochemical balances, hormone disruptions from endocrine disruptors, skin alterations, neurotoxicity, kidney damage, liver damage, bone disease, emphysema, ototoxicity, reproductive damage, and many other fatal diseases. The improper disposal of these hazardous wastes creates fatal health problems, and is a serious public health risk (Municipal solid waste management manual, Govt. of India, 2014).

International Responses to Global Waste Trade Issues

There have been various international responses to the problems associated with the global waste trade and multiple attempts to regulate it for over thirty years. The hazardous waste trade has proven difficult to regulate as there is so much waste being traded, and laws are often difficult to enforce. Furthermore, there are often large loopholes in these international agreements that allow countries and corporations to dump hazardous wastes in dangerous ways. The most notable attempt to regulate the hazardous waste trade has been the Basel Convention (Walsh, 1992).

5.2 Initiatives Related to Waste Management in India

Waste management market comprises of four segments - Municipal Waste, Industrial Waste, Bio-Medical Waste and Electronic Waste Market. All these four types of waste are governed by different laws and policies as is the nature of the waste. In India waste management practice depend upon actual waste generation, primary storage, primary collection, secondary collection and transportation, recycling activity, Treatment and disposal. In India, municipality corporations play very important role in waste management in each city along with public health department. Municipal Corporation is responsible for the management of the MSW generated in the city, among its other duties. The public health department is responsible for sanitation, street cleansing, epidemic control and food adulteration. There is a clear and strong hierarchy of posts in the Municipal Corporation (Agarwal et al., 2015).

Waste Management Initiatives in India During the recent past, the management of solid waste has received considerable attention from the Central and State Governments and local (municipal) authorities in India. A number of partnerships/alliances are found to exist in the field of solid waste management in Indian cities. These alliances are public-private, community-public and private-private arrangements. To identify the status of existing alliances in the study area, it is first necessary to identify the various actors working in the field of waste management (Agarwal et al., 2015).

These actors can be grouped as under

- Public sector: this comprises of local authority and local public departments at city level;
- Private-formal sector: this constitutes large and small registered enterprises doing collection, transport, treatment, and disposal and recycling;
- Private-informal sector: this constitutes the small-scale, non-recognized private sector and comprises of waste-pickers, dumppickers, itinerant-waste buyers, traders and non-registered small-scale enterprises; and
- Community representatives in the form of NGOs, etc. These actors enter into partnerships for providing various activities related to solid waste management.

These partnerships can be as follows

- Public-private (Local Authority and private enterprises);
- Public-community (Local Authority and NGOs); etc
- Private-private (waste-pickers, itinerant-waste buyers, waste traders and dealers, wholesalers, small scale and large scale recycling enterprises); and
- Public-private-community (Local Authority, private enterprises and NGOs).

National Solid Waste Association of India (NSWAI) is the only leading professional non-profit organization in the field of Solid Waste Management including Toxic and Hazardous Waste and also Biomedical Waste in India. It was formed on January 25, 1996. NSWAI helps the Ministry of Environment and Forest (MoEF), New Delhi in various fields of solid waste management makes policies and action plans and is entrusted the responsibility of collecting information and various data related to solid waste management from the municipalities of Urban Class-I cities (population more than 1Lakh) and Urban Class-II cities(population above 50,000), collate and disseminate the information to website which is linked to national and international organizations. The other regulatory framework for waste management is related to Indian government Initiatives for waste management under Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Urban Infrastructure Development Scheme for Small & Medium Towns (UIDSSMT), "Recycled Plastics Manufacture and Usage Rules (1999) amended and now known as The Plastics Manufacture and Usage (Amendment) Rules (2003), "Draft Guidelines for Sanitation in Slaughter Houses (1998)" by Central Pollution Control Board (CPCB), Non-biodegradable Garbage (Control) Ordinance, 2006, Municipal Solid Wastes (Management and Handling) Rules, 2000, etc. At the national policy level, the ministry of environment and forests has legislated the Municipal Waste Management and Handling Rules 2000. This law details the practices to be followed by the various municipalities for managing urban waste. Other recent policy documents include the Ministry of Urban Affairs' Shukla Committee's Report (January 2000) the Supreme Court appointed Burman Committee's Report (March 1999), and the Report of the National Plastic Waste Management Task Force (August 1997). In order to get a sense of the current status of sanitation in India's cities, a survey was initiated by the Ministry of Urban Development as a part of the National Rating and Award Scheme for Sanitation in Indian Cities. The methods used for the survey can be found on the Ministry of Urban Development website. The Government of India announced the National Urban Sanitation Policy (NUSP) in 2008. As a part of this, the government proposes to encourage states to develop their own sanitation strategies to tackle their own sanitation problems and meet the goals of the NUSP. The rating and award scheme has been taken up under this policy initiative. Besides all these initiatives Delhi Waste Management (DWM) was formed in 2004 as a Special Purpose Vehicle (SPV) in the Public Private Partnership (PPP) format for collection, segregation and transportation to landfill sites of municipal waste. Over 1000 employees are employed as a part of this initiative. The overall initiatives related to waste management in India can be summed up as follows in the Table 5.1(Agarwal et al., 2015).

Table 5.1 Initiatives related to waste management in India

Policy and Regulation	
Institutional Framework	• Central Level • State Level • Other Organizations/Associations
Legal Framework	• 74th Constitutional Amendment Act, 1992 • Management and Handling Rules • Environment (Protection) Act, 1986 • National Environment Tribunal Act, 1995 • National Environment Appellate Authority Act, 1997 • Water (Prevention & Control of Pollution) Act, 1974 • Water (Prevention & Control of Pollution) Cess Act, 1977
Environmental Norms	• Existing Environmental Standards • Recently Notified Environmental Standards
Policy Initiatives	• National Urban Sanitation Policy, 2008 • National Environment Policy, 2006 • Policy Statement for Abatement of Pollution, 1992 • National Conservation Strategy and Policy Statement on Environment and Development, 1992 • Law Commission Recommendation • Ecomark Scheme, 1991
Key Government Programmes	
JNNURM	• Programme Scope and Structure • Funding • Experience So Far • Experience on Reforms • Issues and Challenges
Total Sanitation Campaign	• Programme Scope and Structure • Funding • Experience So Far • Issues and Challenges
MNRE's Waste-to-Energy Programmes	• Programme Scope and Structure • Experience So Far • Issues and Challenges
Other Programmes	• Integrated Low-Cost Sanitation Scheme • National Biogas and Manure Management Programme
Technology and Practices	
Traditional Technologies	• Landfills • Waste Incineration • Sanitation
Key Projects	• Kolkata: SWM Improvement Project • Kanchrapara: SWM through Citizens' Participation • Kollam: MSW Management Project • Chennai: MSW Project • Navi Mumbai: MSW Management Project • Gurgaon: Ultra Modern Waste Management Plant • Namakkal: Zero Garbage Status • Suryapet: Dustbin Free and Zero Garbage Town • Visakhapatnam: SWM Though Citizens Participation

	• Thiruvananthapuram: Decentralised SWM • CIDCO: SWM System at Areas Adjoining Navi Mumba
Key Initiatives	• Chennai: GPRS Equipped Waste Bin • Ahmedabad: Tapping Methane Gas • Goa: Solid Waste Management Corporation • Nagpur: Bye-Laws to Collect Waste Generated in Hotels • Nagpur: Management of Construction Debris • Akola: CBO for Waste Management • Yavatmal: Door-to-Door Collection of Solid Waste
Rural Waste Management	
Key Projects	• Tamil Nadu: Zero Waste Mgt. at Vellore District • Maharashtra: Slwm at Dhamner Village • Gujarat: Greywater Mgt. at Fathepura Village • Maharashtra: Greywater Mgt. at Wadgaon Village • Nashik: Wastepaper to Pepwood • Kerala: Post-NGP Initiatives at Kattapana Village
Industrial Solid Waste Mgt.	
Key Projects	• Andhra Pradesh: 3.66-MW Power Generation Project • Uttar Pradesh: 6-MW Biomass Cogeneration Power Plant • Other WTE Projects • Kolkata: Waste Minimisation of Small-Scale Industrial Units • Himachal Pradesh: Waste Treatment Plant
Liquid Waste Management	
Key projects	• Noteworthy Water Reuse and Recycling Projects • Industrial Liquid Waste

Source- India Infrastructure Report (2009)

Public–private partnership in MSWM in India Public private partnership (PPP) mode implementation usually happens at ground level when individually neither public services nor private sector can achieve their respective goals and aspirations of stakeholders. MSWM appears to be fit case for PPP mode for Indian scenario as ULBs alone are unable to accomplice the task assigned as per MSWR. An amount of USD 5 billion annually is required to provide adequate MSWM services to Indian Cities (Hanrahan, Srivastava, & Sita, 2006) and this level of finance can be met through PPP mode only to address MSWM-related challenges. In India, the PPP mode is still in nascent stage and there is no success story under MSWM. However, many companies took MSWM challenge as a business opportunity and about 40 projects are running under PPP mode for different segments (segregation at community bin, collection, transportation including waste to energy) of MSWM in India. Some Indian companies involved in MSWM are Zen Global Finance Ltd (RDF), ESSEL Infra (MSWM), Enkem Engineers Ltd (biomethanation in collaboration with Entec, Astria), Future Fuel Engineers (India) Pvt. Ltd (biodegestion in collaboration with ECOTEC, Finland), Global Environmental Engineers Ltd (biodigestion in collaboration with PAQUES Pvt., Netherland), Hanzer Biotech (MSWM), Thermax Ltd (Incineration plants in collaboration, ACWA, UK, Danskrodzone, Denmark and Thermal Process, US), Excel Industries (composting), EDL Power (India) Ltd (Sanitary landfill), SELCO international Ltd (RDF, TIFAC, DST), Ramky (Waste Management Services). Some other international companies working in Indian Market in MSWM sector are EISU, UK, Nellemen, Neilsen, and Rauscvenberger of Denmark, Lunde, TBW and BTA of Germany and Entec, Astria, Hitachi Zosen, Japan, etc. However, attributes for successful partnership are efficient implementation, better services, risk sharing, cost saving, and revenue generation. On the other hand, power sharing, loss of control of ULBs, cost enhancement, unaccountability, political risks, and lack of competitiveness are major threat. To overcome the complications associated with MSWM, both public and private sectors should contribute vigorously. Only with the cooperation of both sectors, the efficiency of ULBs in handling SWM can be enhanced. The relations among various components of the PPP system viz. sociological, economical and managerial aspects should be evaluated. The effectiveness of partnership, well defined relationship, and clear demarcation of role, accountability, and adoptability due to dynamics among the various stakeholders are elementary necessities to make PPP work for MSWM (Ahmed & Ali, 2004).

Kerala is one of the few Indian states that took effective measures to address the waste menace by launching Clean Kerala Mission in 2002. Later, in 2007, Malinya Mukta Keralam campaign was launched that succeeded in creating the conducive environment for a Mission Mode Action Plan to achieve the goal of Clean Kerala. Mission 2002 Strategy revolves around the time-tested slogan of Reduce, Reuse, Recycle and Recover. Phase-I was implemented in 5 Corporations and 26 Municipalities with participation of Women self-help groups, students, NGOs, and volunteers of “Kudumbasrees” along with public servants. Phase-II encompassed another 27 cities and 25 villages. This time it was focused on maximizing recycling as well as recovery of energy and manure using appropriate technological interventions. Clean Kerala Company Ltd collected 187 tons of low-grade plastics from urban local bodies and sent to Neptune Automation for its safe recycling. It has setup a plant to make pyrolysis oil from plastic waste. Further, Kerala is planning to collect and process e-waste—a major urban pollutant. It has entered into MoU with Earth Sense Recycle Pvt. Ltd. Other initiatives to make Kerala plastic free; government has banned use of plastic carry bags/cups/plates/flex boards. Kerala Tourism also launched the “Plastic-Free” campaign at Kovalam beach as part of “Zero-Waste Kovalam,” project. Cloth/paper bags have replaced plastic bags. Campaigns have been launched for segregation, collection, and utilization at source with special attention for scientific management of hazardous waste. Implementation of stringent norms for licensing, selection of appropriate technology and development in institutional capacity at ULB level was primary objective “Zero-Waste Kovalam.” In addition bins were installed for biodegradable waste/paper in school. Uses of vermincomposed/biogas slurry are gainfully utilized in garden. Training of students for making paper bags, cloth bags, and waste management in school curriculum are also being encouraged (sanitation. kerala.gov.in).

Initiatives taken by Private Companies

There are various private companies that are providing complete solutions for waste management. For example, Subhash Projects and Marketing Limited (SPML) is a leading Engineering and Infrastructure development organization with 26 years in Water, Power and Infrastructure. Today SPML is surging ahead in Urban Infrastructure, Solid Waste Management, Water and Waste Water Systems, Cross Country Pipelines, Ports and SEZs, through BOOT/PPP initiatives. “SPML Enviro” is an integrated environment solution provider arm of Subhash Projects and Marketing Limited (SPML). It provides complete solution in relation to collection, transportation & disposal of municipal / hazardous waste, segregation and recycling of municipal waste, construction & management of sanitary landfill, construction & operation of compost plant and waste to energy plant at the Delhi airport and Hyderabad Airport. SPML Enviro has invested in the necessary resources and partnerships to provide solid and water treatment solutions. It expertise includes solid waste-to-resources' solutions – universal, industrial and medical waste. SPML Enviro has teamed up with PEAT International, North Illinois, USA, a waste-to-resources company specializing in treating and converting waste to usable resources. PEAT's proprietary Plasma Thermal Destruction Recovery (PTDR) technology is an environmentally friendly process, that converts wastes into non-toxic synthetic gas (which is a valuable source of alternative energy) and other useful end-products. The PTDR is a proven, cost-effective, environmentally clean and commercially viable solution for waste remediation. SPML Enviro together with its joint-venture partners, has proven capabilities to successfully execute projects on turn-key basis involving Okhla sewage treatment plant, Delhi Jal Board, Bewana common effluent treatment, Delhi State Industrial Development Corporation, Delhi State Industrial Development Corporation, Yelahanka primary/tertiary sewage treatment plant, Bangalore Water Supply and Sewerage Board, Okhla common effluent treatment plant, Sewage treatment plant, Mysore, Karnataka water supply and sewerage board, etc. SPML has also formed a joint venture with the US based Company INSITUFORM Technologies (INC.). INSITUFORM is a pioneer in sewer rehabilitation projects worldwide. The Company brings with them a No Dig Technology, that eliminates replacement of old sewers. In this, pipe within a pipe concept - a liner is inserted into the sewer, which makes it as good as new. Initiatives taken by Indian corporate In India, there are various initiatives taken by many corporations. For example, HCL Info system believes that the producers of electronic goods are responsible for facilitating an environmentally friendly disposal, once the product has reached the end of its life. HCL Info system supports the ongoing initiative for separate e-waste legislation in India. HCL has been working on an easy, convenient and safe programme for recycling of e-waste in India. HCL has created the online process of e-waste recycling request registration, where customers (both individual and corporate) can register their requests for disposal of their e-waste. Apart from corporate customers, HCL has extended its e-waste collection program to retail customers also through its HCL Touch spread points spread across the country HCL extends the recycling facility to its users regardless of the fact, when and where they purchased the product. To promote recycling of electronic waste, Nokia India launched a 'Take Back' campaign where customers can drop their old handset in the company's stores and win gifts. The take-back campaign is aimed at educating mobile phone users on the importance of recycling e-waste. As a part of this initiative, Nokia encourage mobile phone users to dispose their used handsets and accessories such as charges and handsets, regardless of the brand, at any of the recycling bins set up across Nokia Priority Dealers and Nokia Care Centers. ITC Ltd has chosen energy management, environmental & waste management and social & farm forestry as major focus areas for CSR. Specific processes include recycling/reuse of paper mill back water for dilution of bleached pulp, recycling of paper machine primary clarifier outlet water for miscellaneous uses, etc. These are few examples to show that Indian corporate is not behind in producing initiatives related to waste management. Challenges in India Key issues and challenges include lack of collection and segregation at source, scarcity of land, dumping of e-waste, lack of awareness, etc. Simple dumping of mixed waste is the practice followed practically everywhere and especially in the developing countries as they cannot mobilize financial resources for applying expensive technology propounded by the developed countries. In India, "The new Municipal Solid Waste Management Rules 2000", which came into effect from

January 2004, fail, even to manage waste in a cyclic process. Waste management still is a linear system of collection and disposal, creating health and environmental hazards (Agarwal et al., 2015).

For developing countries, recycling of waste is the most economically viable option available both in terms of employment generation for the urban poor with no skills and investment.

An effective Solid Waste Management system should aim at minimizing manual handling and 100 % collection & transportation of solid wastes should be achieved. In solid waste management, one thing became very clear that segregation at source is to be practiced. There are lots of initiatives to manage wastes but goes in vein because of not identifying wealth in wastes. In India, we cannot afford sanitary land filling as land is precious here and there are lot of municipalities who do not have land as trenching ground. The source segregation needs lot of study on human behavior against waste littering. For example, the municipality of Bangalore has a parallel scheme, "Swaccha Bangalore", which levies mandatory fees for all households, businesses and educational institutions to increase its financial resources. These user fees imply that the residents will expect the municipality to provide proper waste collection services. It integrates them into the overall waste management strategy in all localities thereby helping to reduce the amount of wastes going outside the locality.

For example, EXNORA is an NGO in Chennai that focuses on the environment through their solid waste management program, which works in municipalities throughout Tamil Nadu. In fact, despite the lack of proper legal and financial support by public agencies, the informal sector has a firm standing and gives an invaluable service to a large section of the society in relation to waste management (Agarwal et al., 2015).

It is observed from various case studies of developing countries like Latin America, Egypt, etc. that if waste pickers and recyclers get official recognition from the local authorities and they organize themselves and institutionalize their activities, there is an overall improvement in the living conditions of these people. Micro-enterprises in the field of solid waste management sector are a new process in India and only few examples are available. The Self-Employed Women's Association (SEWA), Ahmedabad, India successfully improved the living conditions of women paper pickers, by organizing them into cooperatives and by searching for easily accessible raw materials in bulk quantity.

There are several missing links and many loose ends both in terms of management, technology and professional skill. The solutions need thorough understanding, for example, deployment of competent persons qualified in solid waste management (real hard taskmasters and not people who turn up with a handkerchief to cover their nose to keep the stink away), application of efficient combination of waste handling equipment in cost effective manner and streamlining of the handling of waste at various stages throughout its journey from source of generation to ultimate safe disposal site, without intermediate dumping and accumulation of waste for days together. A flawless continuous flow sheet of waste management has to be developed. Matching financial support, discipline and attitudinal change in all concerned will obviously be the key for effective and successful waste management in India (Agarwal et al., 2015).

In order to make proper waste management activity sustain in true sense, following other points need to be given attention to – 1) Region specific planning: Looking at the geographical, topographical and cultural diversity of the country it can be divided into five regions such as Northern region, Eastern region, Western region, Central region and Southern region. Each of these regions has different structure. Hence all the activities should be planned & implemented on regional basis. 2) Planning from below: To make Solid Waste Management a success in true sense, the planning as well as implementation should start from general public level planning followed by block level planning, district level planning and state level planning. 3) Involvement of self-help groups, youth groups and small entrepreneurs: The general public level waste management units can be run by self-help groups, youth groups or small entrepreneurs. This will help in making the programme self-supportive and sustainable. 4) Well planned and effective training policy: Technical training at all levels (General public to state) forms the backbone of a successful waste management programme. Adequate training must be given to all those concerned prior to actual launching of the programme in the field (Agarwal et al., 2015).

Science and Technology for Sustainable Development: "3R" Action Plan and Progress on Implementation (Excerpt):

As we continue to implement the G8 Action Plan on Science and Technology for Sustainable Development adopted at Evian, we commit to launching the Reduce, Reuse, and Recycle ("3R") Initiative to encourage more efficient use of resources and materials. The initiative will be formally launched in the coming year at a ministerial meeting in Japan.

Reduce, Reuse and Recycle Initiative:

We will launch the Reduce, Reuse, and Recycle ("3R") Initiative at a Ministerial Conference in spring 2005 hosted by the Government of Japan. In cooperation with relevant international organizations such as the OECD, we will seek through this initiative to:

- Reduce waste, Reuse and Recycle resources and products to the extent economically feasible;
- Reduce barriers to the international flow of goods and materials for recycling and remanufacturing, recycled and remanufactured products, and cleaner, more efficient technologies, consistent with existing environmental and trade obligations and frameworks;
- Encourage cooperation among various stakeholders (central governments, local governments, the private sector, NGOs and communities), including voluntary and market-based activities;
- Promote science and technology suitable for 3Rs; and
- Cooperate with developing countries in such areas as capacity building, raising public awareness, human resource development and implementation of recycling projects.

5.3 Case studies

3 R initiatives

Science and Technology for Sustainable Development: "3R" Action Plan and Progress on Implementation (Excerpt)

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- Promote science and technology suitable for 3Rs; and
- Cooperate with developing countries in such areas as capacity building, raising public awareness, human resource development and implementation of recycling projects.

Mysore with population of 9 lakhs generates 420 T of wastes.

- 50% of the wastes arrive at a processing site are made windrow and composted. Turning and presence of plastics favours supply of oxygen.
- After 45 days sieved and shredded and allowed of 15 days composting by spreading inoculum. Plastics sold to the recyclers.
- Crushed and sieved compost are packed and sold.

Coimbatore city with population of 16 lakhs generates 750 T of wastes. The wastes have 45% of compostable organics.

- Composting (350 T) and RDF (220 T) are followed and 20% of the wastes are land filled.
- Composting consists of screening, windrow, shredding, screening
- Sanitary landfill sites are used for disposal of inert/rejects.

Namakkal with population 1,70, 000 generates 46 T of wastes and only 30 T of waste is collected. The segregated 25 T waste is processed by vermicomposting and windrow composting. It contains 45% bio-degradable.

Waste Management and Landfilling in Germany

Municipal solid waste in Germany started to decline after peaking at 52.8 million tonnes in 2002. By 2014, the country generated 50.1 million tonnes of MSW. Germany was among the first in Europe to introduce policies to limit landfilling in the 1990s. Measures included schemes for collecting packaging waste, bio-waste and waste paper, separately. By 2014, the level of recycling was 64 per cent. While 35 per cent of the waste is incinerated, landfilling has been brought down to as low as 1 per cent - one of the lowest in the world (Eurostat, 2016). The requirement of pre-treatment of MSW before it can be landfilled combined with enforcement of regulations such as the introduction of separate collection and producer responsibility, have been strong drivers in diverting MSW away from landfills and towards recycling. Ban on the landfilling of non-pre-treated MSW in Germany was introduced in two steps using three legislations (1993, 2001 and 2002). The country, in 2006 itself, fulfilled the EU Landfill Directive that calls for all the member states to reduce the amount of biodegradable municipal waste landfilled by prescribed percentage by 2006, 2009 and 2016. The ban on non-pre-treated waste, fully enforced in 2005, has had a huge impact on the amount of MSW recovered and landfilled. In countries with a low landfill share and high recycling rates, waste treatment has a positive impact on greenhouse gas emissions, reducing emissions from the economy as a whole. Between 2005 and 2015, emissions of GHG from solid waste sector in Germany nearly halved to 10.1 million tonnes (UNFCCC 2017). Going forward, Germany has set increased recycling targets for packaging waste materials and directed producer responsibility organisations to better align fees for packaging with their recyclability.

Recycling and Waste Management in Japan

Between 2006 and 2015, Japan's GHG emissions from solid waste sector declined by about 18 per cent (UNFCCC 2017). From a peak of 54.8 million tonnes in 2000, Japan brought down its waste generation to 44.9 million tonnes in 2013. Of this 22 per cent was recycled, 75 per cent incinerated, and about 10 per cent was sent to landfills. There are lessons to be learnt from Japan in its practice of recycling in general and Extended Producer Responsibility in particular. Business operators are required to reduce the generation of container and packaging waste in Japan by cutting the thickness and weight of containers and packaging, charging fees for plastic shopping bags received from the store, and using returnable containers (Containers & Packaging Recycling Act, 1995). They must recycle containers and packaging used (including from imports) in their business operations. Recycling operations are typically outsourced to Corporations designated by the Containers and Packaging Recycling Act. Manufacturers of electrical appliances are responsible to recycle the waste from the home appliances received from retailers, while the cost of collection, transportation and recycling is covered by the consumers (waste generators) themselves (Home Appliance Recycling Act, 1998). The Automobile Recycling Act of 2002 requires that anyone buying an automobile has to deposit a recycling fee in a fund management corpus of the Japan Automobile Recycling Promotion Centre and has to deliver the automobile back to the dealer when putting the vehicle out of service. The dealer accepts the end-of-life automobile from its owner and provides a certificate of acceptance to the owner. A vehicle dismantler dismantles the automobile for recovery of recyclable parts and metal which are then delivered to automobile manufacturers for reuse. While incineration looms large in the solid waste management in Japan, and in 2013 there were 1172 decentralised incinerators, they are fitted with state of the art emission control technologies to ensure that there is no adverse impact on the environment

Reduction of Industrial Waste Generation by Proper Handling and Management of Waste Materials

Site of the Intervention: Bommasandra Industrial Area, MREVA
Manufacturing Plant
Type of Intervention;
Handling & Managing Waste Materials
Industry: Automobile

Company Profile

Mahindra Reva Electric Vehicles Private Limited, formerly known as the Reva Electric Car Company, is anIndian company based in Bangalore, involved in designing and manufacturing of compact electric vehicles.

Reva was acquired by Indian conglomerate Mahindra & Mahindra in May 2010.

Business Challenge as Opportunity

Mahindra Reva strives to manage and reduce waste material generated by the plant, which would in turn cut down their environmental impact. Mahindra Reva's waste management processes aims to treat maximum amount of waste within the plant premises by segregating waste material into categories, handling scrap through proper identification, recycling and reusing leading to cost benefits and also management hazardous waste material with care to protect environment from pollution and degradation.

Strategy Employed

- Segregation of waste material into different categories
- Proper identification of scrap material
- Waste materials generated during construction was disposed off within plant premises.
- Management of hazardous waste conducted in accordance with all applicable legal other requirements.

Devising the Intervention

Mahindra Reva strives to align all processes and resources with proper handling of waste, thereby effectively reducing all forms of waste in everyday function through the medium of various waste management initiatives.

The major intervention were:

- Within the plant colour coded bins are used to segregate wastes into different categories like bio degradable,non-bio degradable, metallic and hazardous wastes.
- All scrap materials are declared as scrap material only with approval.
- All chemicals are kept in separate containers and handled separately.
- All wastes are disposed through approved waste disposal agencies.
- Records are maintained for date of scrap disposal, agency name, scrap quantity, type, etc.

Municipal Solid Waste and Hazardous Waste Management by Polycrack Technology & CFL Crusher

Site of the Intervention: Bangalore
Type of Intervention: Polycrack technology & CFL crusher
Industry: IT and Consulting

Company Profile
Infosys is a global leader in consulting, technology and outsourcing solutions. As a proven partner focused on building tomorrow's enterprise, Infosys enables clients in more than 30 countries to outperform the competition and stay ahead of the innovation curve. Infosys help enterprises transform and thrive in a changing world through strategic consulting, operational leadership and the co-creation of breakthrough solutions, including those in mobility, sustainability, big data and cloud computing.

Business Challenge as Opportunity
Certain categories of waste are challenging to manage due to lack of adequate treatment facilities andinappropriate disposal methods. Treating unsegregated solid waste and ensuring hazardous waste likeCFLs and tube lights is being disposed in an environment friendly way, stand as a major challenge for most corporates. Infosys focuses to minimize environment impacts and derive value out of waste, through innovative technologies to find solutions for mixed waste, hazardous waste, recyclable plastic waste, etc.

CFLs contain around 3.5–6 mg of mercury per lamp. Mercury exposure has ill effects on human health,adversely affecting the central nervous system, lungs, kidneys, skin and reproductive system. Hence, it was a challenge for Infosys to dispose CFLs and tube lights in a safe and healthy manner and mitigate related carbon emissions. To counter this, the CFL crusher system were installed in Bangalore campus, the first potable crusher in this sector.

In order to extract maximum value from waste Infosys identified significant opportunity in treating municipal solid waste using Polycrack Technology. This technology produces valuable by products that can be used as alternative sources of fuels for industrial and other purposes.

Strategy Employed

Polycrack Technology

Advantage:

- Reduces waste going to landfills
- Minimizes emissions from waste
- Produces reusable products from waste- oil, gas and char
- Oil can be used in furnace burners and boilers
- Further refinement of oil to separate kerosene, petrol, and diesel
- Gas can be used as fuel
- Char can be used as soil conditioner

Municipal Solid Waste and Hazardous Waste Management by Polycrack Technology & CFL Crusher

Disadvantages

- Char produced from waste treatment contains impurities and requires further processing for reuse.
- The catalyst in polycrack needs to be replaced after three batches of recycling.
- CFL crusher

Advantage

- Recycles more than 99 per cent hazardous mercury vapours in CFLs and tube lights
- Prevents intoxication of air, water and soil by mercury
- Minimizes the adverse health effects caused due to mercury exposure
- Portable equipment

Devising the Intervention

Polycrack technology converts municipal solid waste into products like gas, char and oil that can be reused for varied purposes. This technology differs from other pyrolysis technologies in multiple unique ways. For example, it has the ability to process both segregated and unsegregated municipal solid waste and process composite non-recyclable materials such as biscuit, chips wrappers, etc. It also makes the separation of metal from input feed convenient as the operating temperature does not exceed 400 °C. Waste is converted into valuable products which can be further utilized for fuelling vehicles, heating, in boilers, etc., adding value to waste.

CFL crushers separate hazardous mercury from CFLs and tube lights which have inherent adverse effects

if not disposed cautiously. They are often damaged during transportation and their breakage leads to the

release of mercury vapour into the atmosphere, which is highly toxic and may prove to cause severe health and environment damages. The CFL crusher is a portable equipment which can be installed in decentralized facilities, thus reducing the risk of release of mercury during transport. This technology has the ability to erode the ill-effects caused due to mercury contamination and in turn reduce the greenhouse gas emissions (GHG) emissions. This is one of the first portable crusher installed in this sector.

The main purpose of implementing these novel technologies is to eliminate the harmful environmental damages caused due to disposing waste unscientifically, minimize our carbon emissions and ensure a healthy environment for all.

Summary

The global waste trade is the international trade of waste between countries for further treatment, disposal, or recycling. The hazardous waste trade has disastrous effects upon the environment and natural ecosystems. Various studies explore how the concentrations of persistent organic pollutants have poisoned the areas surrounding the dump sites, killing numerous birds, fish, and other wildlife. Toxic colonialism, defined as the process by which “underdeveloped states are used as inexpensive alternatives for the export or disposal of hazardous waste pollution by developed states. Electronic waste, also known as e-waste, refers to discarded electrical or electronic devices.Incinerator ash is the ash produced when incinerators burn waste in order to dispose of it. Lots of efforts are being taken by Indian Govt. to reduce waste.

To Do Activities

1. Discuss international trade of waste and its relevance to India.
2. Discuss initiatives taken by firms to reduce waste management.
3. Visit to municipality near to you and study its waste management process.
4. Conduct an e-waste collection drive at your college/ department. Identify the different varieties of gadgets collected. Send them to a certified e-waste handler in your town.
5. Think out of the box and bring out own ideas for replacing disposables. Is it possible to scale up an idea to a business level? Explore with the student(s) and support in every possible way.
6. Discuss on what topics each student is interested in, scope out possibilities of career development, research or internship opportunities

Films

1. How fast fashion adds to the world's clothing problem, Duration 22 min https://www.youtube.com/watch?v=elU32XNj8PM
2. A cluttered life: Middle class abundance. Duration 19 min. https://www.youtube.com/watch?v=3AhSNsBs2Y0
3. Why I live a zero-waste life, Lauren Singer, TEDxTeen Duration: 14 min https://www.youtube.com/watch?v=pF72px2R3Hg&feature=youtu.be

Books for Reference

1. Collapse: How Complex Societies Choose to Fail or Survive, Jared Diamond
    a. Environmental Engineering Series - Environmental Management by T.V.Rama Chandra & Vijay Kulkarni
2. Text book of Solid Wastes Management by Naved Ahsan & Iqbal H.khan
3. Wealth from Waste - Agricultural food and chemical Processing Waste by S.C.Bhatia
4. Integrated Solid Waste Management, Engineering Principles and Management Issues by George TehoBanglous Hilary Theisen Samuel A. Vigal
5. Solid Waste Management of Municipalities Dr P.S Ajith & Dr P.N. Hari Kumar
6. Solid Waste Management - Present and Future Challenges - Jagbir Singh & AL Ramanathan
7. Smart Cities - Transforming India - Prof M.P Dube
8. Environmental Engineering Series - Management of Municipal Solid Waste - T.V.Rama Chandra

9. Textbook of Environmental Studies for Undergraduate Courses by ErachBharucha
10. Environmental Studies by R. Rajagopalan
11. Environmental pollution control engineering by C.S. Rao
12. Waste Management Practices by John Pichtel
13. Solid wastes management by Stephen Burnley
14. Eco-Economy: Building an Economy For The Earth by Lester R.Brown
15. Environmental Law and Policy in India: Cases, Materials, and Statutes by Armin Rosencranz and Shyam Divan
16. Environmental Law in India by P. Leelakrishnan
17. Not in My Backyard - Solid Waste Mgmt in Indian Cities by Sunita Narain& Swati Singh Sambyal
18. Environmental and Pollution Laws In India by Justice T S Doabia

Reading Material

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4. Ban on scrap import: http://greatforest.com/sustainability101/china-ban-what-to-do/ https://www.wastedive.com/news/china-situation-scrap-import-green-fence-national-sword-blue-sky/520306/
5. Bioaccumulation and Biomagnification: University of Wollogong, Australia and Greenpeace, UK https:/www.uow.edu.au/~sharonb/STS300/science/regulation/infoprinciple.html
6. Steel Scrap: Institute of Scrap Recycling Industries (ISRI), U.S.A
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8. Bioreactor Landfill: https://www.wm.com/sustainability/pdfs/bioreactorbrochure.pdf
9. Bioremediation: https://www.slideshare.net/WaqasAzeem1/bioremediation-of-contaminated-soils
10. Cartridge based Razor:http://www.greatrecovery.org.uk/resources/3682/
11. Extended Producers Responsibility: https://www.oecd.org/environment/waste/Session_1-EPR-Toxics-Link1-Ravi_Agarwal.pdf
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23. Reverse Logistics: https://www.ecomena.org/reverse-logistics
24. Sikkim: The Logical Indian, Story by Prakash Chandra Bhatt
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26. http://timesofindia.indiatimes.com/articleshow/48026617.cms?utm_source=contentofinterest&utm _medium=text&utm_campaign=cppst

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Block 4

Resource Efficiency and Recovery

Swachhta Action Plan

Mahatma Gandhi National Council of Rural Education

Department of Higher Education

Ministry of Human Resource Development, Government of India

Hyderabad - 500004

सत्यमेव जयते

विश्वं पुष्टं ग्रामे अस्मिन् अनातुरम्

Where there is Rural Wellbeing there is Universal Prosperity

Contents

Resource Efficiency & Resource Recovery –An Introduction

The earth is a closed system, and has finite resources. Human beings throughout civilization have learnt the art of resources utilization from the surrounding natural environments, to satisfy and sustain their need from resources in his environment. Man and material relation is known since ages, this relationship is established through different eras from the Stone Age to Digital era. The human capabilities to extract materials to process and produce desired products for consumption and convenience vouches for skills beyond doubt.

The dawn of the industrial era saw production scales exponentially growing and seeded change of lifestyles and production patterns. Urbanization during the last 50 years, brought a change in lifestyle patters at large, and also strongly influenced industrial production patterns for economic development through consumption. This phenomena is more visible in the last 30 years and currently urban societies across the globe are consuming beyond the planet's capacity. India is experiencing similar changes in production and consumption patterns, for the past 2 decades.

[i]The planet is organic in nature and dynamic in behavior, it sets limits to resources exploitation and natural assimilation process of the generated waste. The exploitation and assimilation process surpassing the threshold limits of the Earth's carrying capacity, is manifested through environmental degradation, resource rapid depletion, and contamination. The cumulative impact of anthropogenic activities triggered series of chain reactions in the natural systems resulting changes in global climatic patters, which are manifesting through climate disasters.

To address these unsustainable production and consumption patterns it is vital to reorient the existing production-consumption linear path models, which is against the inherent nature and behavior of Earth and its operation systems. The circular model of production-consumption promotes a sustainable economy and falls in line with the Earth's organic nature and dynamic behavior. The circular model of consumption and production facilitates in establishing symbiotic relation and synergy to enhance Resource Efficiency and Recovery. This strategy reduces the pressure on virgin resources and ensures availability of healthy and productive resources.

Chapter 1-Resource Efficiency and Resource Recovery

Introduction

Over the last three decades, the Indian economy has experienced dynamic transformation with rapid changes to social fabric, economic growth, expanding industrial and service-related production, rise in average income, a booming middle class, rapid urbanisation and a growing population. These changes have been reinforced by increased scale and intensity of resource use leading to intensified diverse demand for natural resources, especially materials. Thus, concerns over resource depletion and constraints manifesting in resource supply constraints, price shocks and rapid degradation of natural resource base have become more evident. These changes have larger economic, social, political and environmental consequences. Particularly, resource extraction, utilisation and disposal stressing the environment and environmental services, many of which, particularly climate change, are becoming severe and are being borne disproportionately by the poor and vulnerable. Therefore, judicious use of resources through a combination of conservation and efficiency measures for economic, social and environmental sustainability is in every society's interest.

[ii]In an increasingly resource deprived world, the challenge for a developing country like India is to find a sustainable balance between developmental needs and reducing the negative impacts associated with resource use. Developed countries need to reduce their overall resource footprint steadily, a rapidly developing country like India will need to increase its overall resource consumption in the short-to-medium term in order to meet its developmental goals. Therefore, efficient use of resources, recovery and reuse of resources is essential for India in order to achieve Sustainable Development Goals, falling in-line with SDG Goal12 – Responsible Consumption and Production.

Objective

The unit focuses to equip the student to understand and realize the importance of transformation of economy from liner to circular, with a prime objective to enhance resource effect and recovery. Give the students an insight into the concepts of Resource Efficiency and Resource Recovery, the importance in today's economy and market, challenges &opportunities, linkage to SDGs, concepts of Circular Economy, challenges of Resource Scarcity, tools and methodology for Life Cycle Assessment, and Strategies for Zero Waste. This module looks into the environment, social and economic aspects of these concept and how to competently execute in business scenarios with the help of success case studies.

1.1 Resource Efficiency & Resource Recovery

[iii]Resource efficiency or resource productivity, is the ratio between a given benefit or result and the natural resource use required for it.

Resource efficiency refers to optimization of the supply of finances, materials, human resources, and other assets that can be drawn on by a person or institution to function effectively, with minimum wasted (natural) resource expenses. It means using the Earth's limited resources in a sustainable manner while minimising environmental impact.

To understand resource efficiency, we first need indicators of the extent and nature of resource inputs and their relationship to economic outputs globally, nationally and at smaller scales of production, such as individual sectors. Consumption-focused indicators, which measure the resources used in products and services across their whole life cycle, are also valuable, particularly for understanding and designing policy to address resource use embedded in international trade.

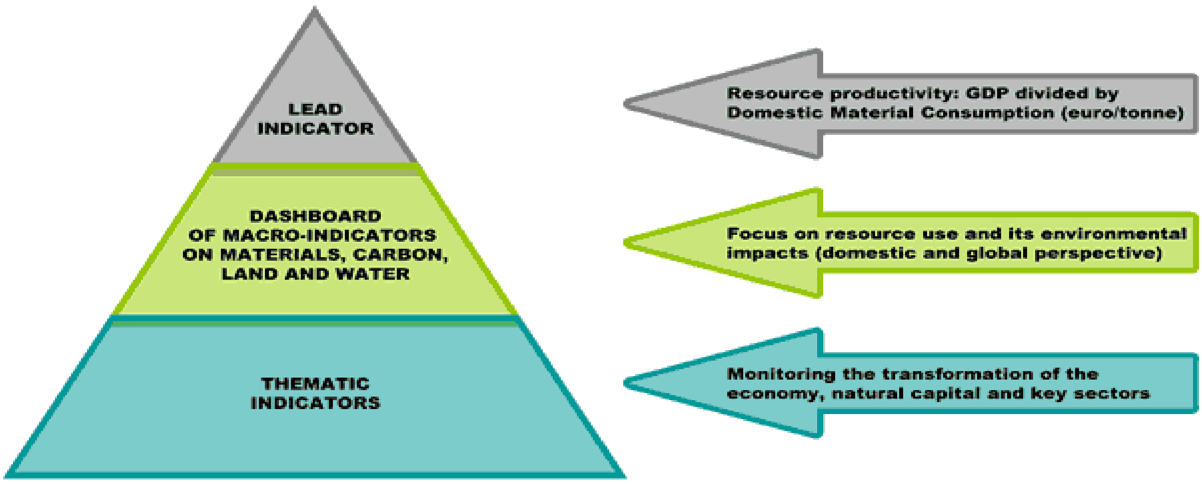


Fig 1.1 Resource Efficiency Indicators

The unsustainable use of resources has prompted critical scarcities and triggered anthropogenic climate change and widespread environmental degradation – all of which have negative impacts on the well-being of the planet and its people.

ivResponding to this dual challenge will require innovative policies, redirected investment, environmentally sound technologies, international cooperation, and capacity development to support countries to transition to inclusive green economies. Producers will need to change how they design, source, manufacture and market their products. Consumers will need to incorporate environmental and social concerns into their consumption decisions and adopt sustainable lifestyles.

Impotence of Resource Efficiency

vRecognising that the planet's economic activities rely on the global ecosystem and its capacity to provide resources and to absorb pollution and waste; is essential to understanding the need for Resource Efficiency. Importantly, the Earth is a closed material system and that shapes the possibilities for economic growth.

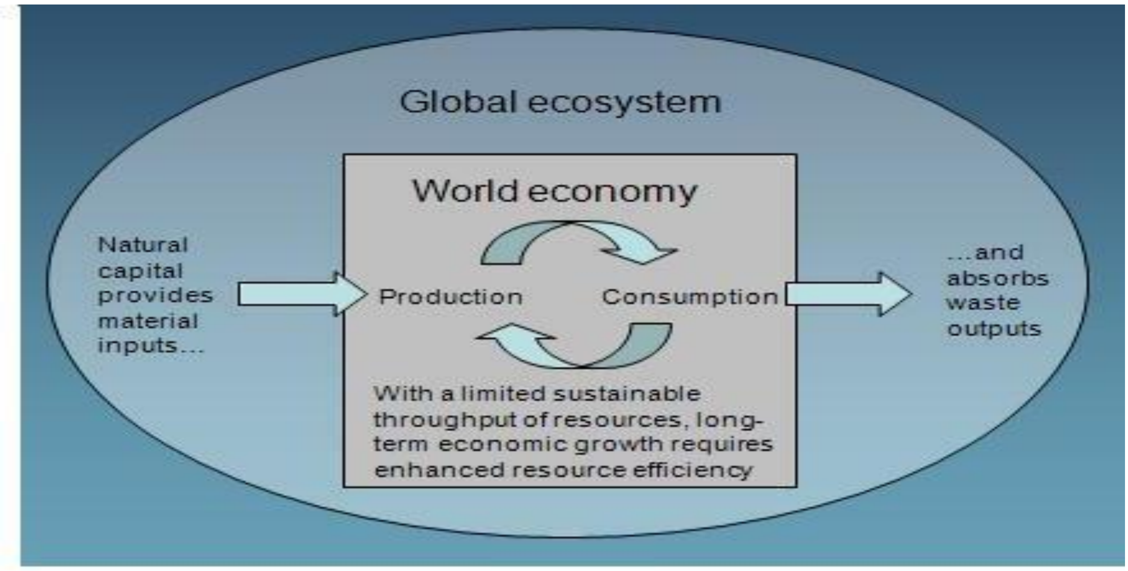


Fig 1. 2 Recourse Efficiency

Some non-renewable resources, including many metals and minerals, security of supply isn't yet a concern; for others, such as fossil fuels, high-tech metals and land, availability is already a problem. Natural systems can also be seen as a form of capital. If we maintain our natural capital it will provide hugely valuable renewable resources and ecosystem services: generating food and fibers, regulating the climate, purifying water and so on. But over-exploiting our natural capital, for example by taking too many resources or emitting excessive pollutants, will reduce its ability to provide further goods and services.

viPut simply, humanity can't keep taking ever more resources from the environment and generating ever more waste. Once the flow of resources through the economy has reached its maximum sustainable limit (and many would argue that we've already passed that point for some resources), the only way to maintain economic growth in the long run is to become more resource efficient finding ways to generate greater returns from the same amount of resources. Resource efficiency isn't only valuable because it is essential for sustained economic growth. Reducing environmental impacts also contributes to well-being derived outside the market.

viiResource efficiency is a strategy to achieve the maximum possible benefit with least possible resource input. Fostering resource efficiency aims at governing and intensifying resource utilisation in a purposeful and effective way. Such judicious resource use brings about multiple benefits along the three dimensions of sustainable development - economic, social and environmental. Sustainable Development, by its very definition, must also take into consideration three critical aspects related to resource equity and access. Firstly, that all human beings, regardless of their location in the global socio-economic-environmental matrix, must have access to a minimum level of income and environmental quality for a dignified sustenance. Secondly, it also must ensure that the benefits, burdens and risks of resource use and conservation are equitably distributed in society. Thirdly, resource efficient production and consumption practices must take into account the needs of future generations by conserving access to resources.

Resource Efficiency – Indian Context

India is meeting its material demand for resources predominantly domestically; thus, most of the impacts of material extraction, use and disposal occur domestically impacting a sizeable population negatively. If India triples its material demand within about 20 years, the question arises where do the required raw materials come from and what are the associated social, economic and environmental implications?

viiiTripling domestic resource extraction of biomass, minerals and fossil fuels will be linked to increasing pressure on natural resources such as land, forest, air and water. Mining activity, for example, has already led to large-scale destruction of forests, displacement of millions accompanied by loss of land and livelihood for many (CSE, 2008). Owing to deteriorating socio-environmental conditions, the opposition of tribals and other local communities against mining has increased during recent years. Thus, further significant increase of mining activity will lead to even more social and environmental conflicts than today.

Imports of materials also face severe constraints import dependencies and costs for imports would increase. Moreover, 3.8 billion tonnes of fossil fuels or 4.6 billion tonnes of construction minerals annually would be further required. It would mean that India would have to import about 2/3rd of internationally traded fossil fuels or about 4.5 times more the amount of non-metal minerals in 2010.

Environmental Challenges and Opportunities

ixReduced extraction pressures due to adoption of Resource Efficiency strategies will help to reduce ecological degradation and pollution associated with mining. Mineral rich areas overlap with heavily forested areas in the country, for e.g. around 60% coal resources are located in forest. By 2025, area under extraction for coal mining would increase from 22,000 hectares to 73,000 hectares (Ministry of Coal, 2015). This would further increase pressures on the forest, pollution of water bodies and land degradation.

Reduced pressures from mining will provide further opportunities for undertaking landscape restoration and regeneration of degraded mined areas. Reduced waste generation will not only reduce pollution associated with disposal but also save related costs. Finally, resource extraction and use is highly energy intensive; and since our energy system is dominated by fossil fuels, it contributes to significant GHG emissions. Minerals industry contributes to around 32% GHG emissions of India. In 2007. CO2 emissions were to the tune of 131 million tonnes from mineral industry, while the metal sector contributed about 122.7 million tonnes of C0 (Mazumdar, 2009). Furthermore, iron & steel, cement plants, sulfuric acid manufacturers, smelters of copper, zinc, lead ore, etc. are significant contributors of CO2 and SOx (Garg et al., 2002). Indeed, it is unlikely that global climate change mitigation goals can be met without a strong commitment to Resource Efficiency in extraction and manufacturing.

Social Challenges and Opportunities

xIndia’s mineral rich areas are under dense forests and inhabited by indigenous communities. Extraction pressures have contributed significantly to conflicts due to displacement, loss of livelihood and have led to opposition by tribals and other local communities including fishermen in Andhra Pradesh. These social and political conflicts also pose significant threat to internal security. Mining of materials contributes to land degradation and loss due to open cast mining, excavation, stacking of waste dumps, discharge from workshops and construction of tailing ponds.

Reduced extraction pressures due to adoption of Resource Efficiency strategies have the potential to reduce conflict and displacement in mining areas, as well as improve health and welfare of local communities. Resource Efficiency can contribute to improved affordability of and access to resources critical for poverty reduction and human development. For example, the use of recycled aggregates and other secondary raw materials can help protect the soil by reducing impetus for land use conversion from agriculture to soil mining. Resource Efficiency has enormous potential for job creation, not only in the recycling sectors, but also high skilled jobs in innovative design and manufacturing. Finally, Resource Efficiency strategies contribute towards preserving resources for future generations.

Economic Challenges and Opportunities

In 2009, India gained 716 dollars (in purchasing power parity and in constant 2005 terms) per tonne of used material while the global average was at 953 dollars (Dittrich, 2012; SERI, 2012; World Bank, 2012). In manufacturing sector alone Indian companies could save uptoRs. 60.8 billion in material savings by implementing resource efficiency measures (IGEP, 2013). Thereby, it can be inferred that with increasing resource efficiency, GDP per tonne of material used will be increased.

xiResource Efficiency has the potential to improve resource availability that is critical to the growth of industries, which translates into reduced price spikes due to supply constraints or disruptions. By using resources more efficiently, or by utilizing secondary resources, industries can improve competitiveness and profitability, since material cost is typically the largest cost for the manufacturing sector. Resource Efficiency-based innovations can also give industries an edge in the export market, as the experience of global leaders such as Germany and Japan has shown. Scientific mining can help increase recovery of primary and associated materials from mined ores. Thus, the stock of resources can be more effectively utilised. New industries can be created including those in the recycling sector, as well as in innovative design and manufacturing, and India can aspire to become a key innovation hub for Resource Efficiency (like it has for ITES). Finally, reduced import dependence for critical minerals helps to improve the country’s trade balance and promote economic stability.

Case Study of Kirloskar Brothers Limited (KBL)

Objective

To analyze the relevance of and possible challenges in terms of resource efficiency related to the pump industry’s material use through a case study. The case study was on KBL, one of the biggest pump manufacturers in India. The study attempt to answer the following main questions

- Is resource efficiency relevant for a country like India, especially regarding metals?
- What are the main metals used in the production of small and medium pumps in the pump industry and what is the market situation of the most important metal (iron)?
- What initiatives have been undertaken by a pump manufacturer like KBL related to resource efficiency and has it led to an improvement in resource efficiency?
- What are the drivers of resource efficiency for a company such as KBL?

How can resource efficiency be improved in a company such as KBL and the pump industry in India, and what are some lessons for the Indian economy as a whole.

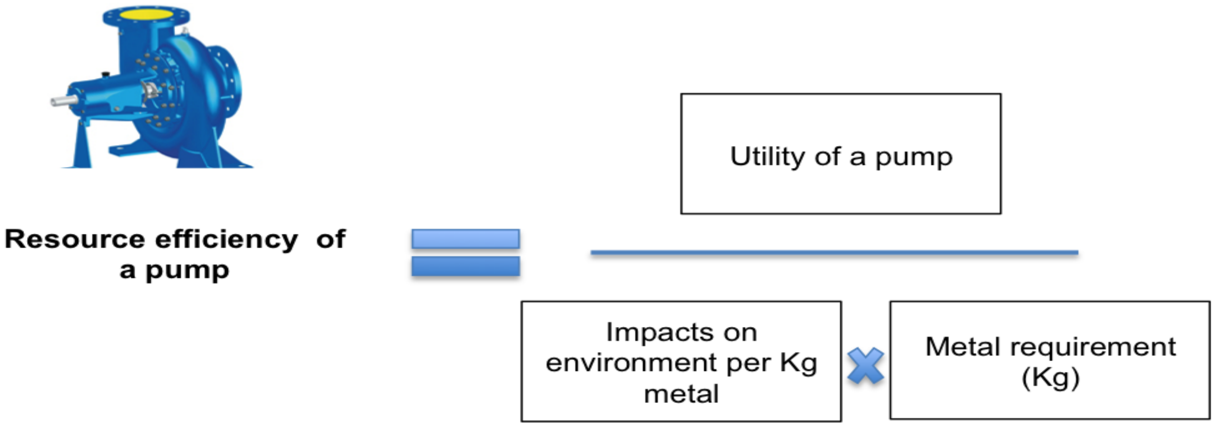


Fig 1.3 – Resource Efficiency Equation (Case Study)

Methodology

To answer these questions, a top down approached was applied. By analysing the material consumption of India as a whole, the biggest metal consuming sectors were identified, and among the manufacturing sector the pump industry was chosen as an example. The material consumption pattern in this sector was analysed and the main metals used for production of pumps were identified. To specifically assess resource efficiency in the Indian pump industry, KBL was chosen as a case study. Through the example of KBL, the drivers, improvements and challenges for resource efficiency in such a company were analysed.

• For measuring resource efficiency, material productivity of the company as well as their initiatives that lead to resource efficiency were assessed, before applying an indicator for resource efficiency to data obtained from KBL, that was defined as follows

To get the data for KBL, Sustainability Reports 2011 - 2013 provided by KBL was the first step in the analysis. For four days during November 2014, site visits were conducted at their Pune headquarters as well as their Dewas manufacturing plant, and different officials from multiple departments such as Sustainability and Business Excellence, Procurement, Design and Engineering, etc. were interviewed. After the visit, KBL provided some more requested data for the analysis; however due of time constraints and business confidentiality issues not all required data was provided. For this reason, some assumptions had to be made. From the analysis, the following key findings and recommendations emerged:

Key findings

• The case study shows that drawing conclusions about KBL's overall resource efficiency is difficult with data sets limited to a specific metal (iron), a specific pump model, or a specific division. As a conclusion it can be said that KBL has taken significant steps in terms of resource efficiency of their pumps with room for improvement.

• Product innovations at KBL to reduce the use of metals are mostly price driven to lower their material cost and increase their competiveness.

• The main metals that the pump industry uses, such as iron, are not resources of immediate concern regarding supply and scarcity. However political issues, like the recent mining bans in some parts of the country, can lead to local/temporary disruptions in supply of such materials.

• Awareness of the topic of resource efficiency is steadily increasing in the international community. However in a country like India, which is estimated to have an increased demand of metals over the next years, the topic of resource efficiency is not yet on the political agenda.

Key recommendations

- Setting compulsory standards for pumps and enforcing them universally would force the pump industry to provide a certain standard quality pumps. This would enhance the utility of a pump both in terms of performance and lifespan and lead to an improvement in resource efficiency.
- The formation of an institutionalized national resource panel and of multi-stakeholder forums on sustainable resource management could act as hubs for promoting resource efficiency in India beyond individual sectors or regional interests.
- Through international cooperation with resource efficiency leaders such as Germany and Japan, India could gain knowledge of best practices in terms of both technology and policy. Detailed studies focusing on critical sectors can identify priority areas for intervention, and international experts can partner with Indian industry to implement showcase projects that can then help to popularize resource efficiency practices.
- When pursuing efforts to promote resource efficiency, a Life Cycle Assessment (LCA) approach should be adopted this would provide a holistic assessment of environmental impacts.

SDGs and Resource Efficiency

Resource Efficiency strategy provide multi-dimensional benefits for sustainable development, judicious use of resources is an important part of several SDGs, most obviously Goal 12 (responsible consumption and production) and Goal 8 (decent work and economic growth), but also those related to sustainable cities and communities (Goal 11), industry, innovation and infrastructure (Goal 9), climate action (Goal 13) and affordable & clean energy (Goal 7). Further, an ambitious Resource Efficiency strategy has the potential to make a substantial contribution to India's Nationally Determined Contributions (NDC) commitments under the 2015 Paris Climate Change Agreement.

Fig 1.4 Resource Efficiency – SDGs Linkage

Resource Recovery

Urbanization is the pre-eminent global phenomenon of our time. Currently, urban areas account for 75% of the world's natural resource consumption, while producing over 50% of the globe's waste on just 2–3% of the earth's land surface (UNEP, 2013). Without recycling, cities will continue to constitute vast sinks for food waste including valuable crop nutrients and organic matter, while millions of rural, peri-urban or urban farmers struggle with depleted soils to feed the growing urban population. Yet, it is not only the loss of valuable, and in part, finite resources, but also the costs of poor waste management, i.e. environmental pollution and the production of avoidable greenhouse gases (GHG) which threatens sustainable urban growth. Halving, for example, the current rate of food wastage would greatly support waste management while reducing GHG emissions by 22–28% (WEF, 2016). So far, the environmental costs of poor waste management are usually externalized and the market incentives to reduce waste are minimal.

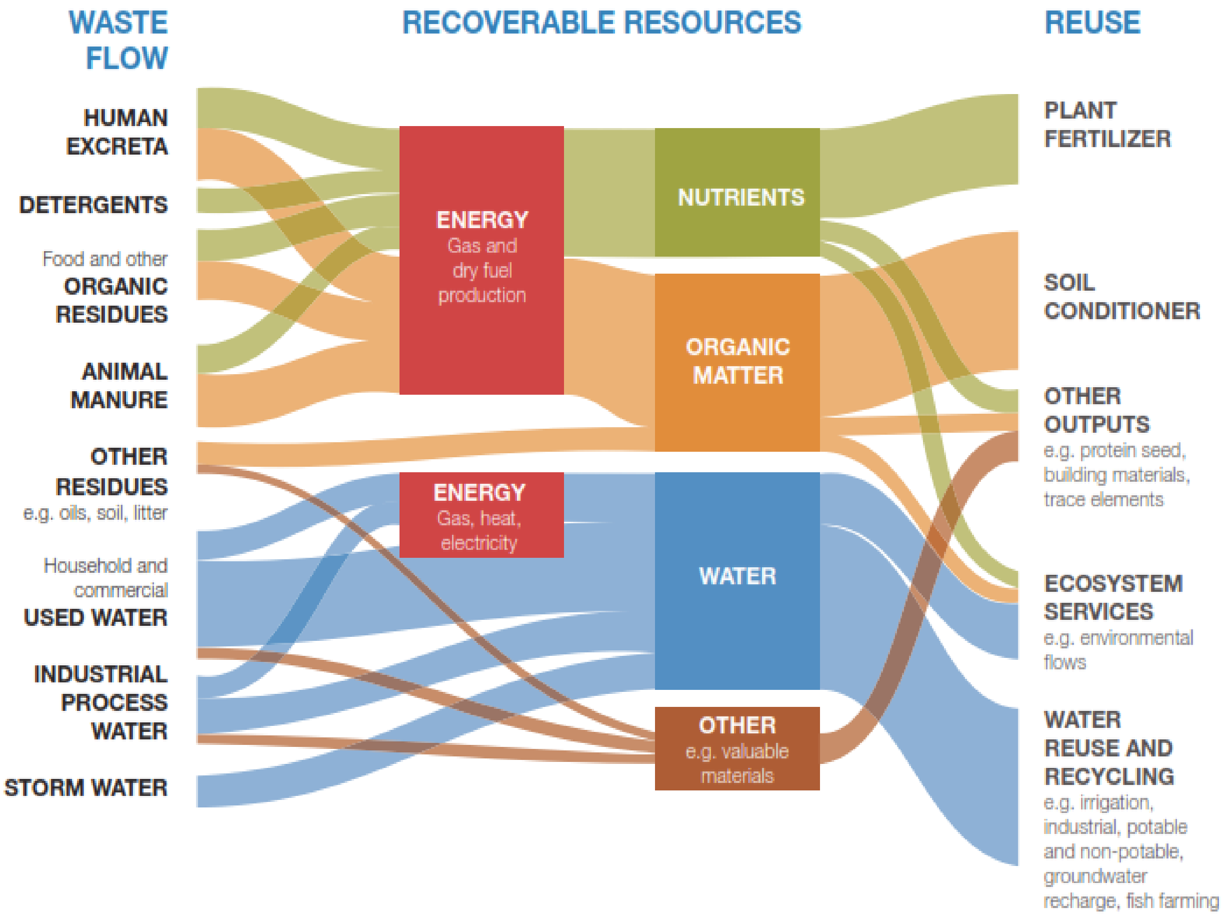


Fig 1.5 Overview of Waste Streams and Resources with Potential for the Recovery and Reuse of Nutrients, Organic Matter, Water and Energy

While global demand projections for water, food and energy predict continuous and significant growth, the declining reserves of the non-renewable phosphorus, copper and zinc resources (Holmgren et al., 2015) reinforce the need for more investments in resource recovery and reuse across the food, waste and sanitation sectors (Ellen MacArthur Foundation, 2017; TBC, 2016).

Definition: Resource recovery is the separation of certain materials from the waste we produce, with the aim of using them again or turning them into new raw materials for use again.

Resource recovery is the removal or separation of materials from the waste stream for activities such as recycling, composting, and waste-to-energy generation. Resource recovery reduces the amount of waste that ends up in landfill by preventing or delaying the extraction and use of virgin materials, extracts maximum benefit.

Why is Resource Recovery important?

[xii]Resource recovery is using wastes as an input material to create valuable products as new outputs.

The aim is to reduce the amount of waste generated, therefore reducing the need for landfill space and also extracting maximum value from waste. Resource recovery delays the need to use raw materials in the manufacturing process. Materials found in municipal solid waste can be used to make new products. Plastic, paper, aluminium, glass and metal are examples of where value can be found in waste.

[xiii]Resource recovery in developing countries contributes to a range of socioeconomic and ecological benefits that affect human well-being including poverty reduction, sustainable natural resource management, food security, ecosystem service functions and improved nutrition and health (Hanjra et al. 2015). Resource recovery addresses concerns about resource scarcity and the negative externalities of waste by harnessing the value of waste materials as productive inputs. A range of technologies, business models and institutional arrangements may be employed for Resource recovery solutions in domestic wastewater treatment and reuse for agriculture or industry, agro-industrial waste management systems, organic municipal solid waste (MSW) management and on-site sanitation of fecal sludge. For example, treated or partially treated wastewater from municipal wastewater treatment plants may be sold or given to farmers, reducing demand for freshwater irrigation and chemical fertilizers by transferring nutrients directly back into the agricultural system (Hussain et al. 2001). Capturing nutrients from fecal sludge and organic solid wastes reduces demand and resource requirements for conventional disposal methods and may reduce the severity of pollution (Cofie 2003). Energy recovery from biogas provides an alternative energy source and contributes to climate change adaptation and mitigation (Hanjra et al. 2015).

Improving the quality of material streams by reducing contamination is an important component to improving resource recovery. Contamination can reduce the volumes and quality of materials recovered. Resource Recover has potential to

- Increase disposal costs for the community and businesses
- Result in safety issues at recycling facilities
- Lead to recoverable materials being sent to landfill
- Lead to materials that are hazardous or toxic being sent to landfill.
- Minimising environmental impacts
- Maximising recovery of materials

Environmental Challenges and Opportunities

Waste dumps have adverse impacts on the environment and public health. Open dumps release methane from decomposition of biodegradable waste under anaerobic conditions. Methane causes fires and explosions and is a major contributor to global warming. There are also problems associated with odour and migration of leachates to receiving waters. Odour is a serious problem, particularly during the summer when average temperatures in India can exceed 45°C. Discarded tyres at dumps collect water, allowing mosquitoes to breed, increasing the risk of diseases such as malaria, dengue and West Nile fever. Uncontrolled burning of waste at dump sites releases fine particles which are a major cause of respiratory disease and cause smog. Open burning of waste and tyres emits 22 000 tonnes of pollutants into the atmosphere around Mumbai every year. The impacts of poor waste management on public health are well documented, with increased incidences of nose and throat infections, breathing.

.Major cities in India and *per capita* waste generation data (2010–2011). Source: *Census of India 2011, #CPCB Report 2011.

city	*population (2011) × 10^6	#total waste generated in tonnes per day	waste generation (kg *per capita* per day)
Ahmedabad	6.3	2300	0.36
Hyderabad	7.7	4200	0.54
Bangalore	8.4	3700	0.44
Chennai	8.6	4500	0.52
Kolkata	14.1	3670	0.26
Delhi	16.3	5800	0.41
Mumbai	18.4	6500	0.35

Table 1.1 Indian Cities' Waste Generation

Megacities are a relatively recent phenomenon, associated with globalization of the economy, culture and technology. [xiv]Megacities in India include Ahmedabad (6.3 million), Hyderabad (7.7 million), Bangalore (8.4 million), Chennai (8.6 million), Kolkata (14.1 million), Delhi (16.3 million) and Greater Mumbai (18.4 million). These have dynamic economic growth and high waste generation per capita, as shown in above table.

Waste management infrastructure has an important role in delivering sustainable development. Rapid population growth in India has led to depletion of natural resources. Wastes are potential resources and effective waste management with resource extraction is fundamental to effective SWM. Value extraction from waste can be materials, energy or nutrients, and this can provide a livelihood for many people. The transition from wastes to resources can only be achieved through investment in SWM as this depends on a coordinated set of actions to develop markets and maximize recovery of reusable/recyclable materials. Materials, energy and nutrient recovery must be the aim of future SWM infrastructure development in India. Resources can be recovered from wastes using existing technologies and India has an extremely effective recycling tradition. The 'scrap dealer' systems produce recycled materials through an extensive and well-coordinated network across the country.

Social Challenges and Opportunities

[xv]Although human health risks associated with solid waste handling and disposal are present in all countries, the problems in developing nations like India are more acute and widespread. The health risks are classified into four main categories: i) presence of human fecal matter ii) presence of potentially hazardous industrial waste iii) the decomposition of solids into constituent chemicals which contaminate air and water systems and iv) the air pollution caused by consistently burning dumps and methane release (Cointreau, 1982). Insects and rodents breed on solid wastes and can spread diseases like cholera and dengue fever. The health risks from waste are caused by many factors, including: The nature of raw waste, its composition (e.g. toxic, allergenic and infectious substances), and its components (e.g. gases, dusts, leachate, sharps); nature of waste as it decomposes (e.g. gases, dusts, leachate, particle sizes) and their change in ability to cause a toxic, allergenic or infectious health response; handling of waste (e.g. working in traffic, shoveling, lifting, equipment vibrations, accidents); processing of wastes (e.g. odor, noise, vibration, accidents, air and water emissions, residuals, explosions, fires); disposal of wastes (e.g. odor, noise, vibration, stability of waste piles, air and water emissions, explosions, fires).

Kerala has achieved high health standards in areas like birth rate, death rate, Infant Mortality Rate (IMR), Life Expectancy, control of infectious diseases, etc. but the state now faces problems like high morbidity rate, re-emergence of infectious diseases, life style diseases etc.(Economic Review ,2004). The table below shows the occurrence of major infectious diseases in Kerala.

Table 1.2 Kerala Health Statistics

Disease	2003	2004	2005	2006	2007	2008
Leptospirosis	1569	1082	1366	1811	1220	1288
Dengue	3546	686	1028	1011	677	734
Chicken guinea	-	-	-	70731	24052	24683
Cholera	61	91	27	12	4	6
Malaria	2586	1584	1322	1805	1203	1481

Source: Directorate of Health Services, Kerala (2008)

Economic Challenges and Opportunities

[xvi]The challenges associated with improper waste disposal could be significantly mitigated by requiring Resource Recovery. Source separation of inert and high moisture content fractions would maximize the potential for thermal recovery and other treatment options in India. The waste processed in thermal recovery is residual waste that remains after all commercially viable recyclable materials have been extracted. Waste-to-energy technologies produce energy, recover materials

and free land that would otherwise be used for dumping. The composition of residual waste is important for energy recovery and waste composition is changing in India, with the amount of high calorific waste generally increasing. A significant increase in the use of waste-to-energytechnologies are available, but this depends on location, climate, demographics and other socioeconomic factors.

[xvii]Waste-to-energy development in India is based on a build, operate and transfer model. Increased waste-to-energy would reduce disposal to land and generate clean, reliable energy from a renewable fuel source, reducing dependence on fossil fuels and reducing GHG emissions. In addition, generation of energy from waste would have significant social and economic benefits for India. However, the track record of waste-to-energy in India highlights some of the difficulties. The vast majority of facilities have not worked effectively due to various operational and design problems. For example, the first large-scale MSW incinerator built at Timarpur, New Delhi in 1987 had a capacity to process 300 tonnes per day and cost Rs. 250 million (US$ 5.7 million). The plant failed because of poor waste segregation, seasonal variations in waste composition and properties, inappropriate technology selection and operational and maintenance issues. Despite this experience, waste-to-energy will have a key role in future waste management in India.

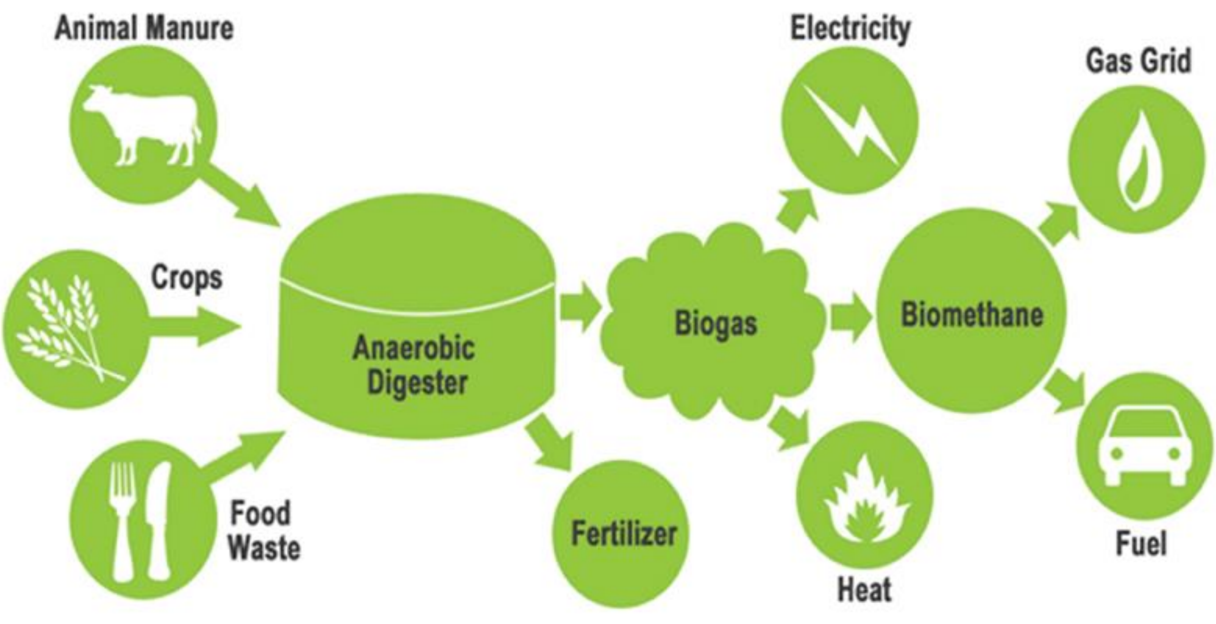


Fig 1.6 Energy Recovery

Since over 50 per cent of the waste generated is organic in nature, there are opportunities for organic waste recovery. Composting organic waste for reuse as manure in agriculture is one way of reducing the environmental problems linked to waste and also as a means of reducing urban poverty. India's trash is a commodity, just like oil or wheat. The Ellen MacArthur Foundation has estimated that implementing circular opportunities in India could yield over $624 billion per annum in material savings by 2050--equivalent to 30% of India's current GDP.

Resource Recovery: Efficient Resource Recovery Options from Municipal Solid Waste: Case Study of Patna, India

[xviii]**Objective**: The study is carried for solid waste management in Patna city. It generates 511 Ton/day solid waste where 51.96% compostable, 12.57% recyclable, 36% moisture and 0.37 kg/c/day waste generation rate with 18.62 C/n ratios. MSW in Patna is disposed of in an unscientific manner without considering environmental impacts. The amount of recovered methane gas is estimated here.

Methodology: A review for municipal solid waste management of India reported physical characteristics of municipal solid waste for many metro cities. So, the physical characteristics of solid waste for Patna city were taken from a study. The typical percentage of moisture content, density and energy content for each component were used to calculate the same for MSW in this study. Chemical composition was estimated for MSW using typical values of MSW component. Chemical characterization was done for carbon, hydrogen, oxygen, nitrogen and sulfur for each component of MSW then the same was calculated for MSW. Afterwards, mass was calculated for chemical composition and chemical formulation was made using molar weight.

Results & Discussion: Moisture content (%), dry mass (kg), volume and total energy for MSW have been calculated in Table 1. The overall moisture content and density for MSW is 35.43% and 204 kg/m. The energy content as discarded solid waste is 8.4 MJ/kg while energy content for dry ash and ash free dry ash are 13 and 14.1 MJ/kg respectively. Here, 5% ash content was assumed. The total MSW generation in Patna city is 511 tons/day and the total dry mass of MSW is 330 tons/day. The total energy content (Dry Ash) is 4.3×10 MJ/day while energy content (Ash free Dry Ash) is 4.4×10^6 MJ/day.

Table 1.3 – Chemical Characterization of Solid Waste

Component	Wet mass (Kg)	Dry mass (kg)	C	H	O	N	S	Ash
Paper	4	3.76	1.64	0.864	5.076	0.351	0.054	0.675
Textile	5	4.5	2.475	0.23	1.65	0.0112	0.007	0.23
Leather	2	9.8	1.08	0.03	1.404	0.207	0.007	0.112
Plastic	6	5.88	3.53	0.144	0.208	0.18	0.007	0.18
Metal	1	0.97	-	0.42	1.34	-	-	0.59
Glass	2	1.96	-	-	-	-	-	-
Ash, fine other	35	32.2	8.47	-	-	-	-	-
Compostable	45	13.5	6.48	0.97	0.64	0.161	0.06	21.896
Total	100	64.57	23.68	2.76	10.32	0.910	0.13	23.68

The oxygen requirement for MWS is 1.9×10^5 kg O2 /day or 1.33×10^8 L of O /day to degrade MSW. The present MSW of Patna city present MSW of Patna city can generate methane gas (Ch4) 2.46×10 kg/day 3.44×10^8 L/day and carbon dioxide (CO2) 5×10 kg/day or 2.55×10^8 L/day. The recovery from solid waste can be utilized to proper landfilling of MSW.

Conclusions Generally, landfill for solid waste management is planned for fifteen years or more than that. It is carried out in several parts or layers which take many years. The calculation of energy content, requirement of oxygen to degrade MSW and recovery of methane, carbon dioxide from MSW have been carried out for a year which can be extended for whole landfill period.

In India and many other developing countries, the segregation, collection, transportation and disposal of municipal solid waste (MSW) are generally done in a very unscientific way presently. This leads problems for environment in terms of water, air and odour pollution.

Resource Recovery – Indian Context

India faces major environmental challenges in Resource Recovery associated with waste generation and inadequate waste collection, transport, treatment and disposal systems. Current systems in India cannot cope with the volumes of waste generated by an increasing urban population, and this impacts on the environment and public health. The challenges and barriers are significant, but so are the opportunities. A priority is to move from reliance on waste dumps that offer no environmental protection, to waste management systems that retain useful resources within the economy. Waste segregation at source and use of specialized waste processing facilities to separate recyclable materials has a key role. Disposal of residual waste after extraction of material resources needs engineered landfill sites and/or investment in waste-to-energy facilities. The potential for energy generation from landfill via methane extraction or thermal treatment is a major opportunity, but a key barrier is the shortage of qualified engineers and environmental professionals with the experience to deliver improved waste management systems in India.

[xix]Despite significant development in social, economic and environmental areas, Waste Management and Resource Recovery systems in India have remained relatively unchanged. The informal sector has a key role in extracting value from waste, with approximately 90% of residual waste currently dumped unscientifically. There is an urgent need to move to more sustainable waste management practices, and this requires new management systems and waste management facilities. Current systems are inefficient, with waste having a negative impact on public health, the environment and the economy. The waste Management and Handling Rules in India were introduced by the Ministry of Environment Forests and Climate Change (MoEF&CC).

1.2 Circular Economy

Looking beyond the current take-make-waste extractive industrial model, a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles

- Design out waste and pollution
- Keep products and materials in use
- Regenerate natural systems

Definition In a circular economy, economic activity builds and rebuilds overall system health. The concept recognises the importance of the economy needing to work effectively at all scales – for large and small businesses, for organisations and individuals, globally and locally.

Transitioning to a circular economy does not only amount to adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits.

What is a Circular Economy?

A circular economy differs from a linear economy in a fundamental way. The main differences are found in the step plan that is followed, the perspective on what sustainability is, and the quality of reuse practices. A linear economy works according to the 'take-make-dispose' step plan. Resources are extracted and products are produced. Products are used until they are discarded and disposed of as waste. Value is created by maximizing the amount of products produced and sold.

A circular economy works according to the 3R approach of “Reduce, Reuse & Recycle”. Material extraction is reduced where possible by using less material. Products are made of reused parts and materials and after discarding a product, materials and parts are recycled. In a circular economy value is created by focusing on value retention. By keeping material streams as pure as possible during the complete value chain, the value of this material is retained. Pure materials streams can be used multiple times to provide a certain functionality or service, while only making one investment.

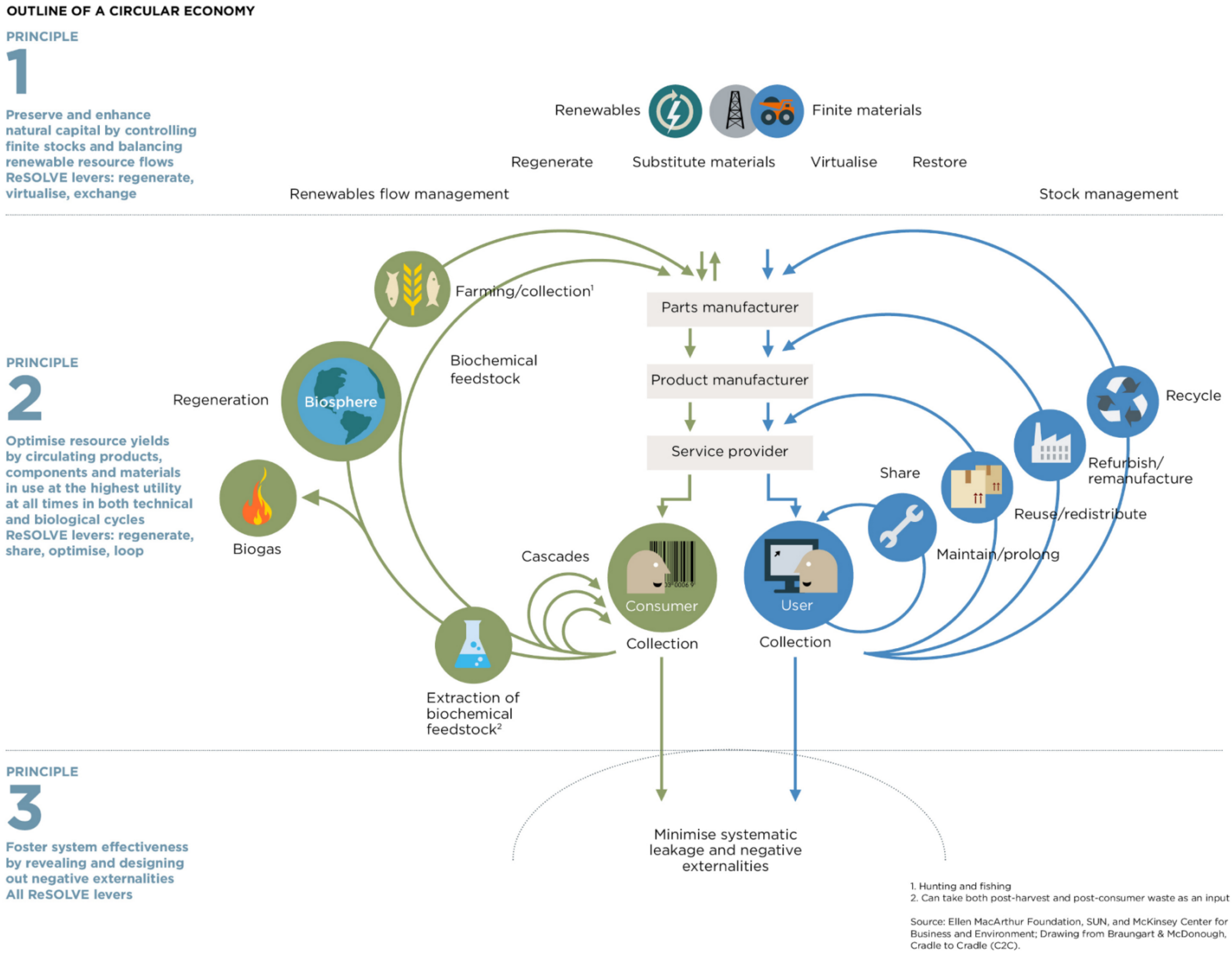


Fig 1.7 Outline of Circular Economy

Circular Economy Schools of Thought

The circular economy concept has deep-rooted origins and cannot be traced back to one single date or author. Its practical applications to modern economic systems and industrial processes, however, have gained momentum since the late 1970s, led by a small number of academics, thought-leaders and businesses.

Cradle to Cradle German chemist and visionary Michael Braungart went on to develop, together with American architect Bill McDonough, the Cradle to Cradle™ concept and certification process. This design philosophy considers all material involved in industrial and commercial processes to be nutrients, of which there are two main categories: technical and biological. The Cradle to Cradle framework focuses on design for effectiveness in terms of products with positive impact and reducing the negative impacts of commerce through efficiency.

Cradle to Cradle design perceives the safe and productive processes of nature's 'biological metabolism' as a model for developing a 'technical metabolism' flow of industrial materials. Product components can be designed for continuous recovery and reutilisation as biological and technical nutrients within these metabolisms.

- Eliminate the concept of waste. "Waste equals food." Design products and materials with life cycles that are safe for human health and the environment and that can be reused perpetually through biological and technical metabolisms. Create and participate in systems to collect and recover the value of these materials following their use.
- Power with renewable energy. "Use current solar income." Maximize the use of renewable energy.

Respect human & natural systems. "Celebrate diversity." Manage water use to maximize quality, promote healthy ecosystems and respect local impacts. Guide operations and stakeholder relationships using social responsibility.

Performance Economy

Walter Stahel, architect and industrial analyst, sketched in his 1976 research report to the European Commission 'The Potential for Substituting Manpower for Energy', co-authored with Genevieve Reday, the vision of an economy in loops (or circular economy) and its impact on job creation, economic competitiveness, resource savings, and waste prevention. Credited with having coined the expression "Cradle to Cradle" in the late 1970s, Stahel worked at developing a "closed loop" approach to production processes and created the Product Life Institute in Geneva more than 25 years ago. It pursues four main goals: product-life extension, long-life goods, reconditioning activities, and waste prevention. It also insists on the importance of selling services rather than products, an idea referred to as the 'functional service economy', now more widely subsumed into the notion of 'performance economy'. Stahel argues that the circular economy should be considered a framework: as a generic notion, the circular economy draws on several more specific approaches that gravitate around a set of basic principles.

Biomimicry

Janine Benyus, author of Biomimicry: Innovation Inspired by Nature, defines her approach as 'a new discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems'. Studying a leaf to invent a better solar cell is an example. She thinks of it as 'innovation inspired by nature'. Biomimicry relies on three key principles:

- Nature as model: Study nature's models and emulate these forms, process, systems, and strategies to solve human problems.
- Nature as measure: Use an ecological standard to judge the sustainability of our innovations.
- Nature as mentor: View and value nature not based on what we can extract from the natural world, but what we can learn from it.

Industrial Ecology

"Industrial ecology is the study of material and energy flows through industrial systems". Focusing on connections between operators within the 'industrial ecosystem', this approach aims at creating closed-loop processes in which waste serves as an input, thus eliminating the notion of an undesirable by-product. Industrial ecology adopts a systemic point of view, designing production processes in accordance with local ecological constraints whilst looking at their global impact from the outset, and attempting to shape them so they perform as close to living systems as possible. This framework is sometimes referred to as the 'science of sustainability', given its interdisciplinary nature, and its principles can also be applied in the services sector. With an emphasis on natural capital restoration, industrial ecology also focuses on social wellbeing.

Natural Capitalism

“Natural capital" refers to the world’s stocks of natural assets including soil, air, water and all living things. In their book “Natural Capitalism: Creating the Next Industrial Revolution”, Paul Hawken, Amory Lovins and L. Hunter Lovins describe a global economy in which business and environmental interests overlap, recognising the interdependencies that exist between the production and use of human-made capital and flows of natural capital. The following four principles underpin natural capitalism

- Radically increase the productivity of natural resources - Through radical changes to design, production and technology, natural resources can be made to last much longer than they currently do. The resulting savings in cost, capital investment and time will help to implement the other principles.
- Shift to biologically inspired production models and materials - Natural capitalism seeks to eliminate the concept of waste by modelling closed-loop production systems on nature’s designs where every output is either returned harmlessly to the ecosystem as a nutrient, or becomes an input for another manufacturing process.
- Move to a “service-and-flow” business model - Providing value as a continuous flow of services rather than the traditional sale-of-goods model aligns the interests of providers and customers in a way that rewards resource productivity.
- Reinvest in natural capital - As human needs expand and pressures on natural capital mount, the need to restore and regenerate natural resources increases.

Circular Economy Case Study - ITC eChoupal

[xx]Agriculture is the backbone of Indian economy producing 23 percent of GDP, and employs 66 percent of workforce. Because of the green revolution, India’s agricultural productivity has improves to the point that it is both self-sufficient and a net exporter of a variety of food grains, yet most Indian farmers have remained poor. The causes include remnants of scarcity-era regulation and an agricultural system based on small, inefficient land holdings. The other constraints are weak infrastructure, numerous intermediaries, excessive dependence on the monsoon variation between different agro-climate zones, and many others. The unfortunate result is inconsistent quality and uncompetitive prices, making it difficult for the farmers to sell his produce in the world market. ITC’s trail-blazing answer to these problem is the - e-choupal initiative; the single largest information technology-based intervention by a corporate entity in rural India that is transforming the Indian farmer into progressive knowledge-seeking netizens. Enriching the knowledge of farmers & elevating them to a new order of empowerment. ITC aims to confer the power of expert knowledge on even

the smallest individual farmer enhancing its competitiveness in the global market.

ITC in conjunction with local farmers created the e-choupal system that is acting as a catalyst in rural transformation by providing access to latest information of the agro sector, developing local leadership and creating a profitable distribution. It helps in alleviating rural isolation, improves productivity and income, create transparency for farmers - which improves the economic condition of rural areas.

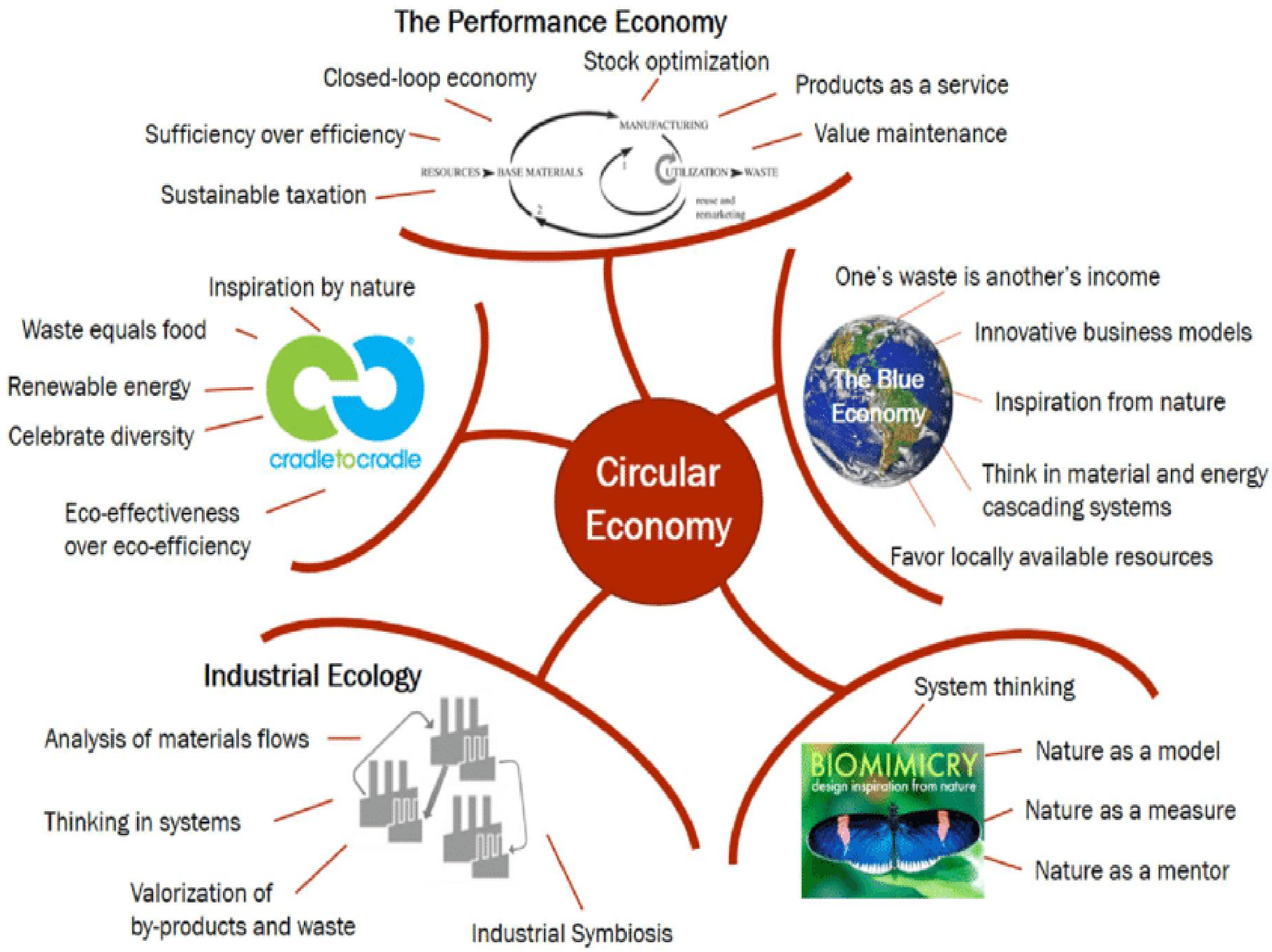


Fig 1.8 – The influence of the various schools of thought on circular economy

e-choupal: e-choupal is a Hindi word which means – "Village meeting place". e-choupal is virtual market place where farmers can transact directly with a processor and can realize better price for their produce. e-choupal makes use of the; physical transmission capabilities of current intermediaries & aggregation, logistics, counter-party risk and bridge financing. In June 2000, ITC Limited launched e-choupal in India and now e-choupal has become the largest Internet based intervention in rural India.

The e-choupal business model: The model is centred on a network of e-choupal, information centres equipped with computer connected to the Internet, locating in rural farming villages. e-choupal serves as choupal (gathering place) and an e-commerce hub. A local farmer acting as a Sanchalak (coordinator) runs the e-choupal and the computer usually is located in the sanchalak's home. ITC also incorporated a local commission agent known as the Samyojak (collaborator), into the system as the provider of logistical support. The critical element of the e-choupal system and the key to managing the geographical and cultural breath of ITC's network by recruiting a local farmer is the sanchalak. Sanchalak create trust in society and all infrastructure set up is made in his house. Sanchalak receives commission for every transaction processed through the e-choupal and also benefited from increased social status that accompanies the position – a significant advantage in rural Indian life. Sanchalak act as public officer in ITC project. Sanchalak also aggregates farmers input as well as purchase orders. Sanchalak undergoes training of basic computer usage, basic business skills, quality inspection of crop product training etc. The samyojak or cooperating commission agents also play important role. He earn income by providing logistical services that substitute for the lack of rural infrastructure by providing information and market signals on trading transaction. Samyojak is involved in ongoing operation of e-choupal system, allowing them revenue streams through providing services such as management of cash, bagging & labour at procurement hubs, handling of mandi paperwork as licensed principals for the retail transaction of the e-choupal.ITC has plans to saturate the sector in which it works with e-choupals, such that a farmer has to travel no more than 5kms. The company expects each e-choupal to serve about 10 villages.

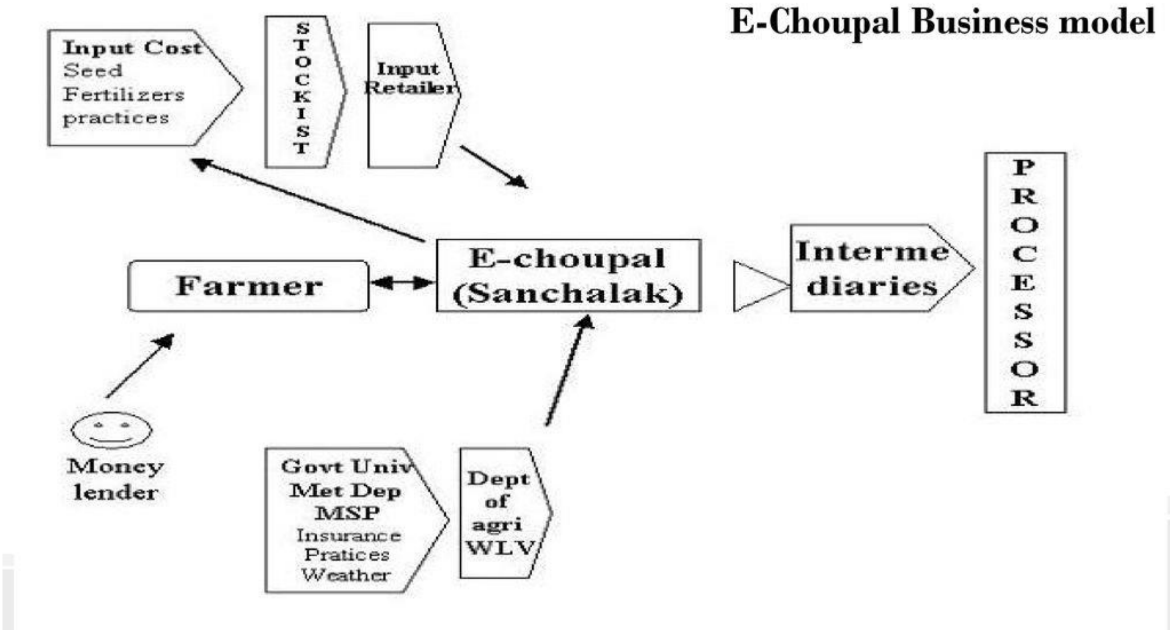


Fig 1.9 – e-choupal Business Model

The e-choupal Cost and revenue Stream: e-choupal has been successful. It has reduced the cost of procurement and the cost of transit and the material handling cost. Procurement transaction costs are reduced from the industry standard of 8 percent (farmers incurs 3percent and the processor incurs 5 percent) to 2 percent(with farmer saving all his 3 percent, and the processor ITC– saving 3 percent).The total cost incurred on the initiatives so far has beenRs.50 million (Rs.35 million as capital cost towards computers and other hardware at the kiosks as well as central servers and Rs.15 million revenue expenditure incurred towards portal development, people overhead etc.). But ITC has gain benefit Rs. 20 million, which is the equivalent of full investment on 40 percent of the Choupals (Kiosks). In terms of future revenue, the outflow is 52.1 million in 2001-02 which reduces to 3.90 millionin 2005-2006 and for 2006-07 is estimated as 2.70 million. Whereas inflow in 2001-02 is 15.3 million where as 65.0 million in 2005-2006 and estimated as 85.0 million in 2006-2007. The internal rate of return (IRR) on the project works out to be 21.55percent.

Conclusion

[xxi] Farmers are already reporting the benefits from using e-Choupal. Data on acreage and yield between 2000-2012, shows that profits of farmers accessing the e-Choupal platform almost tripled. Soya farmers learned how to apply scientific farming practices to reduce seed use from 40-45 kg per acre to 30-35. In 2015, four million farmers used the service via 6,500 e-Choupal access points spread over 40,000 villages in 11 states. There are direct advantages for ITC too. By eliminating superfluous steps in the supply chain, the company lower its net procurement costs, despite offering better prices to farmers.

Table 1.4 Comparison – Conventional Market Vs e-Choupal

Conventional transaction vs. e-choupal		
Cost	ConventionalMarket	e-choupalTrolley
Freight	100	NIL
Filling & Weighing	70	NIL
LabourKhadiKarai	50	NIL
Handling loss	50	NIL
Sub total	**270**	**NIL**
Processor Incurs – CommissionAgent	100	50
Cost of Bag	75	NIL
Labour (Stitching & loading)	35	NIL
Labour at factory (Unloading)	35	35
Freight to factory	250	100
Transit Losses	10	NIL
Sub Total	**505**	**185**
Grand Total	**775**	**185**

Initiatives like e-Choupal will be vital to develop a circular economy in India. The Ellen MacArthur Foundation's 2016 report estimated that applying circular economy principles to the Indian food system could create annual benefits of ₹3.9 lakh crore (USD 61 billion) in 2050; reduce emissions, water usage, and environmental degradation; and play a vital role in securing the long-term food supply. The study specifically highlights 'digitally enabled asset- and knowledge-sharing solutions' and 'digitised food supply chains' as two opportunities to increase circularity in the Indian food system. These are areas in which e-Choupal is already having a significant impact.

The circular economy gives purpose to the digital transformation. By using the internet to put sophisticated data in the hands of farmers, ITC helps small and medium size businesses increase profits through better decision-making to optimise the use and distribution of time and resources.

1.3 Resource Security

Resources are the life blood of manufacturing. Without a clear view of supply risks and an active and ambitious strategy to manage those risks, businesses will be increasingly vulnerable to price volatility, supply chain disruption and business continuity risks. Susanne Baker, AIEMA, EEF and Chair of Materials Security Working Group

[xxii]Scarcity of resources and the impact of climate change are of growing economic concern. Demand for energy is forecast to increase by as much as 50% by 2030, and water withdrawals by 40%. Impacts may include increases in extreme weather and rising sea levels, which could make traditional methods of farming, hunting, and fishing difficult or impossible in some places. The need for sustainable solutions may well be at odds with the need for resources to fuel growth and feed populations. Time-honored traditions will be challenged by changes to the physical environment.

[xxiii]There are implications for developing economies when it comes to charting out their specific growth paths. Finite resources are depleting by each passing year and the earth has crossed the threshold where it can replete these resources. In 2018, August the 1st was Earth overshoot day3 which signifies that within 7 months of the entire year, mankind consumed resources which the earth would have taken at least 12 months to replenish. This also signifies the excess carbon which is being generated through increased consumption which the earth cannot absorb. It is imperative that resource efficiency is adopted within business models such that material extracted can be put to multiple use through recycling after it has been disposed at end of life. Urban mining in the electronics sector provides a scope for ensuring that different kinds of materials, especially metals,

can be brought into the circular chain, thereby enhancing multiple uses than the typical linear consumption models which have been followed in developed economies.

Organisations are increasingly growing aware of the price they pay for the materials they use, feel the effect of changing prices and struggle to source materials from their normal suppliers on occasions. Since 2000, an increasing array of commodities have seen significant price volatility and constraints in short-term supply, from oil and steel to rare earth minerals (essential to modern communication, electronics and renewable technology). Alongside this, there has been increasing focus on responsible sourcing of materials (eg. palm oil and conflict materials) to avoid businesses contributing to negative environmental and social effects associated with their extraction or production.

While a well-managed forest can supply timber over the medium-term, as a naturally regenerative raw material, there are genuine concerns that increasing global demand could outstrip supply. The consequence would include: increases in the price of timber, paper and related materials; disruption to existing supply chains; and the potential for accelerated deforestation.

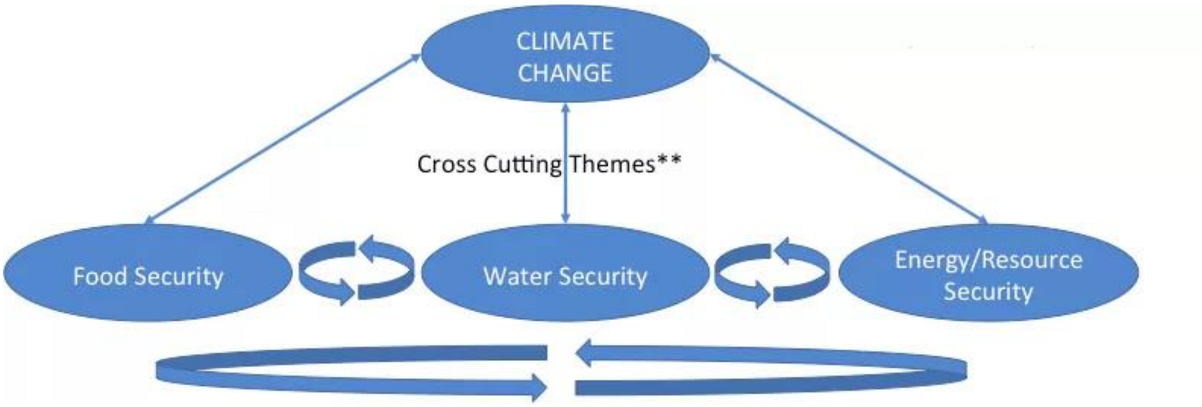


Fig 1.10 – Climate Change Impact on Resource Security

Environmental Impact Resource Security

Recent discussions regarding resource security, besides those focusing on commodity price, can be divided into four broad categories: supply stability, environmental impact, stockpiling and nationalism. Supply stability includes consideration of self-sufficiency, import intensity or substitutability of materials and supplies, including recycling. These discussions focus in part on the promotion of independence from external circumstances, with differentiation between short-term risk and long-term risk. One commonly cited example is China's rare earth element (REE) export restrictions that occurred around 2010. At that time Japan was highly dependent on REE from China, and this restriction of supply from the dominant player in the marketdrove Japanese industries to reduce REE demand through a variety of measures. For example, Honda Motor Co. Ltd. started battery recycling to recover restricted metals, while Hitachi commercialized a rare metal-free motor. This supply risk hit important minor metal components; however, if a similar restriction was to occur for base metals, the effects could be expected to be much broader and to last much longer. Environmental impact refers to factors related to reserves, ore grades, energy consumption or wastes. These are factors potentially affecting the long-term sustainable development of resource exporting countries, which have been posited as potentially reducing cumulative production through direct restrictions on environmental damage or loss of social license. In recent years, climate change has also been seen as having a potential effect on resource supply, with unpredictability due to climate change possibly threatening resource security. Stockpiling indicates a temporary alternative to help buffer the impact of supply restriction, but is only valid for addressing short-term risks.

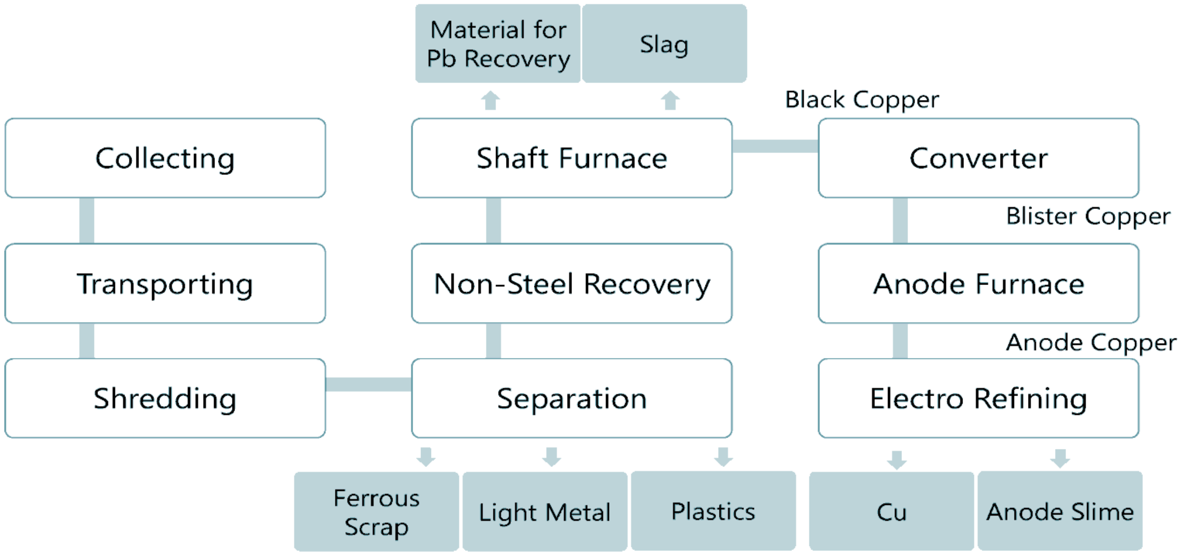


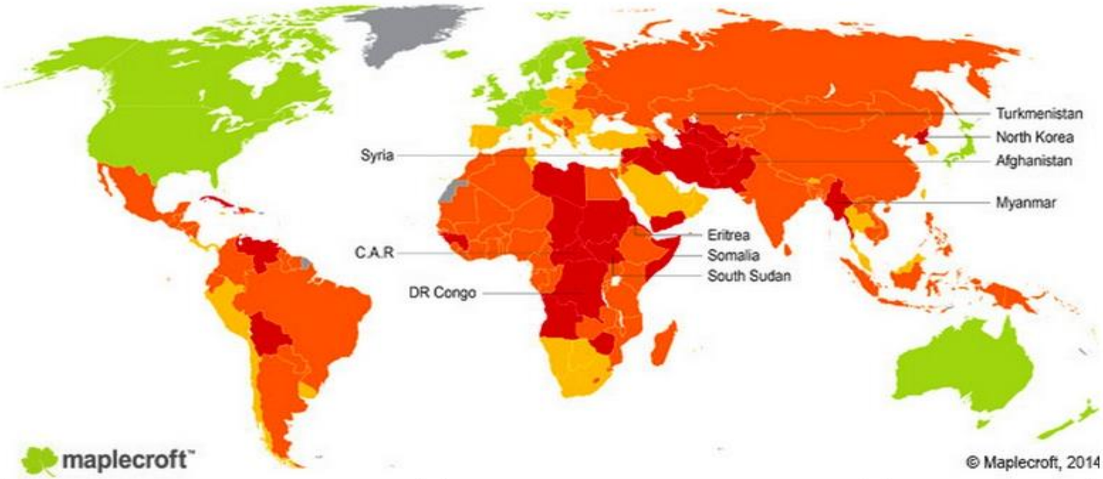
Fig 1.11 – Mineral Resource Recovery

[xxiv]It has widely been forecast that mineral demand will continue to increase across most categories of minerals, with the exception of certain minerals that are deleterious to the environment or health such as mercury or asbestos. Demand increases in the future will be likely to exacerbate resource competition because reserve decline may, in some cases, mean that producers are not able to supply sufficient material to meet the total demand. Ore grade decline, has widely been discussed as a potential future issue as well, with implications for increases in energy and environmental costs.

[xxv]Environmentally inefficient mining may be an operational limitation due to tougher regulations. From this point of view, ore grade may become a limiting factor in future. Demand increases will likely be caused by new technologies, especially renewable energy, electric vehicles or telecommunications, not only in the transition for developed countries but also in the rapid catch-up demand from developing nations. Renewable and clean energy technologies require a wide variety

of metals, both rare and common, and it is important to consider the additional supply that low carbon technology might add to the conventional demand growth.

One example is global copper demand, which has been estimated elsewhere to increase by between 200% and 350% in 2050 compared to 2010, or growth to 31,200 to 54,600 kt per annum based on the USGS. Another estimate indicates growth to 34,000 ktpa in 2050 [21], which shows agreement with an increase of copper consumption of nearly double in the next few decades. The International Copper Association estimates that in 10 years, copper demand for electric vehicles will increase 9 times compared to the demand of 2017, which is likely to exacerbate copper demand beyond historical trends. Moreover, metals like steel and copper can be – and are – recycled. So a 1,400% increase in EVs doesn't necessarily mean an equivalent increase in copper demand, since some of that increased demand could be met from recycling.



Rank	Country	Category
1	Somalia	Extreme
2	North Korea	Extreme
3	Turkmenistan	Extreme
4	DR Congo	Extreme
5	Myanmar	Extreme

Rank	Country	Category
6	Syria	Extreme
7	C.A.R	Extreme
8	South Sudan	Extreme
9	Eritrea	Extreme
10	Afghanistan	Extreme

Legend
Extreme
High
Medium
Low
No data

Fig 1.12 – Recourse Security Environmental Risk Index 2014

But there's no question that the world is going to need a lot more copper, steel, rare earths and several other critical energy metals over the next two decades. The increased mining required will have impacts on land, water, forests and Indigenous peoples.

"A major increase in virgin raw material extraction will have severe consequences for local communities and the environment, including large emissions of greenhouse gases," the European Parliament report warns.

Socio-Economic Impact of Resource Security

There's no doubt about it resource use is freighted with consequences. It inevitably generates emissions and other untoward environmental effects across the entire lifecycle of each and every product. Moreover, growing resource scarcity and fluctuating raw materials prices are provoking severe economic disruption and social unrest.

[xxvi]The high standard of living that we enjoy depends entirely on the availability of natural resources. Apart from abiotic and biotic raw materials, we use water, soil, air, biodiversity and land as habitats and for recreational purposes; and for energy we use wind power, solar power and tidal flows. These resources also serve as emission sinks, waste dumps, and as indispensable production factors for farming and forestry.

The myriad social consequences of resource use are related to issues such as the distribution of raw materials, ready access to clean water, and worldwide food security. Per capita use of raw materials in the world's industrial nations is estimated to be four times greater than in less developed countries. However, while the lion's share of value-added from resource use is generated in industrial nations, less developed nations often bear the brunt of the ecological and social impact of raw material production.

People in the regions in question report abuses such as severe human rights violations or permanent ecological damage in the wake of raw material extraction, which often provokes health problems resulting from air pollution and drinking water contamination. Other consequences include local populations being driven off their land and forced to settle elsewhere – not to mention growing poverty. In areas that suffer these consequences, efforts on the part of companies that engage in mining and similar operations to institute sustainable development are few and far between. Moreover, in some states profits from raw material production are used to finance armed conflicts. According to UN statistics, natural resources play a key role in 40 percent of all intra-state conflicts.

From a product lifecycle standpoint, the developed countries are at least partly responsible for such ecological and social outcomes, by virtue of our increasing dependence on imported raw materials and the products made from them. In some cases this also holds true for sustainable raw materials such as the animal feed and energy crops that we use in such abundance and for which large tracts of fertile land are used. Fertilizer and pesticide use to some extent goes unmonitored, and no protective measures are taken. This can have a negative impact on the health of local populations. Displacement and forced resettlement of local populations, as well as land grabbing, can cripple the food supply of local populations, while non-sustainable production methods often provoke soil degradation and water scarcity, and destroy badly needed fertile land.

In view of the raising concerns of resource security growing number of countries are resorting to resource nationalism. Nationalism, refers to resource nationalism, which is the restriction of exports in order to ensure domestic supply, or increasing export tariffs or applying other measures in order to obtain higher domestic benefit from resources. Resource nationalism has been seen to occur in or among resource-rich countries, particularly developing countries. Resource nationalism factors indicate both risk and driving forces, affecting both short-term and long-term supply. One recent example is the raw material export ban in Indonesia. Under this regulation, the export of unprocessed ores such as nickel or copper ores was prohibited, in order to improve their economy in 2014. Subsequently, nickel ore was not exported until 2017, while copper ore was exported under transition measures. This policy changed in 2017 and these materials could again be exported from 2017. Examining resource security indicators from another perspective, they can be divided into factors that are focused on either the importer or the exporter. Importers are able to deal with the aspects of stable supply and stockpiling, but environmental impacts in producing countries and resource nationalism are largely out of the control of importers. These various factors need to be considered when mineral supply and risk reduction strategies are proposed.

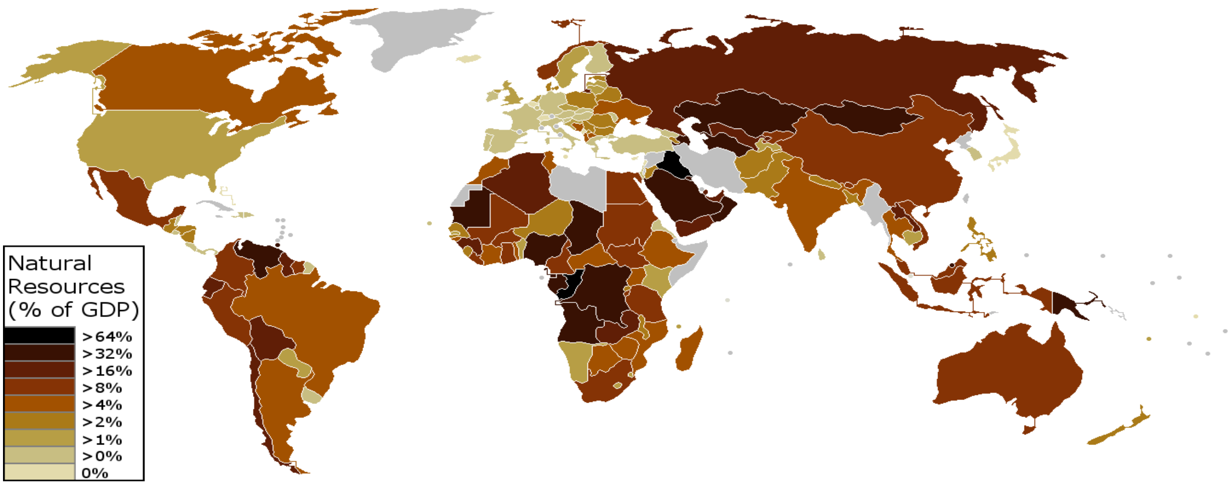


Fig 1.13 – Natural Resources as % of GDP, 2014

[xxvii]Resource security also goes beyond the critical water, food, energy and climate nexus. Many rare metals we have never or seldom used before have become indispensable for sustainable clean energy, computers and mobile devices. We need over 60 such critical materials for wind and solar fuel generation, lighting, making batteries, to build electric and hybrid cars, smartphones and tablets.

Increasing demand and the rare nature of many of these materials can lead to critical shortfalls and put severe limitations on renewable energy technologies.

The challenges raised by this megatrend can be tackled through innovation, new solutions and new industries as well as initiatives such as the UN's Sustainable Development Goals. Despite some positive developments in clean technology, this megatrend is accelerating. We must dare to imagine radically new solutions for a radically different future.

Resource Security Strategies

Resource policy in resource importing countries has historically tended to focus on upstream development in resource producing countries and downstream improvements including research and development on substitute materials. Unconventional resources in the form of recycled materials have been focused on by some, but primary unconventional resources of deep ocean minerals remain beyond the practical scope of most resource security evaluation, due to the uncertainties in extractive economics. However, considering the uncertainty of resource supply in the future, relying on resource producing countries is not an optimal solution from the perspective of long-term resource security. In this context, domestic mineral production is an important alternative to consider for future supply.

There are alternative resources for resource importing countries such as the reopening of mines that were previously closed due to ore grade decline, safety or economics under previous eras' technology.

It is possible that ore grades of closed mines may be higher than cut-off grades today, due to both the increase in prices and the improvement in technology. When countries whose resource policy previously changed from producing domestically to importing concentrate shift their policy again to restarting-mining, localized environmental impacts and energy consumption issues arise.

Energy consumption is another issue to be discussed. The results show that the conventional copper process consumes more energy than recycling or multiple metal recovery from deep ocean mining, when considering the whole supply chain. A key factor for developing a competitive strategy in terms of energy consumption is multiple metal production from either deep ocean mining or recycling.As recycling is further improved, countries need to fiedalternative, secure energy resources to maintain its mineral production, along with the remainder of its economy.On the other hand, even if recycling were to become a dominant raw material supply stream, it still consumes imported energy. Renewable energy technology installation is therefore one of the requirements toachieve a more resource-secure society.

By minimizing energy consumption, CO_2 emissions and waste disposal based on the capacitylimitations of each supply source, it is indicated that installing processes that recover all materials fromrecycling on a priority basis will reduce these impacts significantly. If large-scale deep ocean mining extraction is conducted, it is obvious that this type of material supply can improve resource securitysignificantly. However, as shown in the results, the optimal solution found in this study was utilizingdeep ocean mining at a level of 30% of raw material supply if all metals are recovered from the ore,with the rest of demand filled by recycling. Even though there are some challenges, such as how tofind more deep ocean hydrothermal ore (particularly higher grade ore), it can be said that realizingdomestic mineral production could help to achieve stable resource supply.

It can be concluded that (1) domestic mineral production is one option to obtain resources soas to avoid vulnerability of external affairs. Supply controllability of domestic mineral production should be a key factor in evaluating the sustainability of supply; and (2), based on supply capacity,enterprises, installing recycling will improve resource security while also enabling better performance in terms of energy consumption, CO2 emissions and waste disposal. Considered within the framework of criticality, the combination of pressures from increasing demand globally with potential lags in primary supply could promote domestic mineral production. On the other hand, domestic productionenvironmental implications could work to restrict their output or development, increasing the mineral criticality. For countries considering such options for reducing supply risk, the environmental considerations should also be factored in.

1.4 Life Cycle Assessment

Life Cycle Assessment (German: "Ökobilanz") is a method defined by standards ISO EN 14040 and 14044 to analyse environmental aspects and impact of product systems.

What is Life Cycle Assessment (LCA)?

[xxviii]Life cycle assessment (LCA) is a comprehensive environmental accounting tool with well-established procedures and methods that are governed by specific rules and standards, most notably those developed by the International Organization for Standardization (ISO). LCA's use continues to increase and there are now many experienced LCA practitioners world-wide who have successfully applied LCA across a broad range of industry sectors.

As illustrated in the below diagram, LCA is an approach that covers the whole life cycle of a product or a service, usually "from cradle-to-grave", i.e. from raw material extraction, to manufacturing, packaging, distribution, use and end of life. Process steps are identified for each stage in the life cycle. The inputs (materials and energy) and outputs (emissions and pollutants) are determined for each step. The inputs and outputs are then grouped into impact categories, which are categories of environmental problems. Typical impact indicators include abiotic depletion, acidification, climate change, human toxicity, ecological toxicity, eutrophication, fossil fuel depletion, photo-oxidant smog formation and stratospheric ozone depletion.

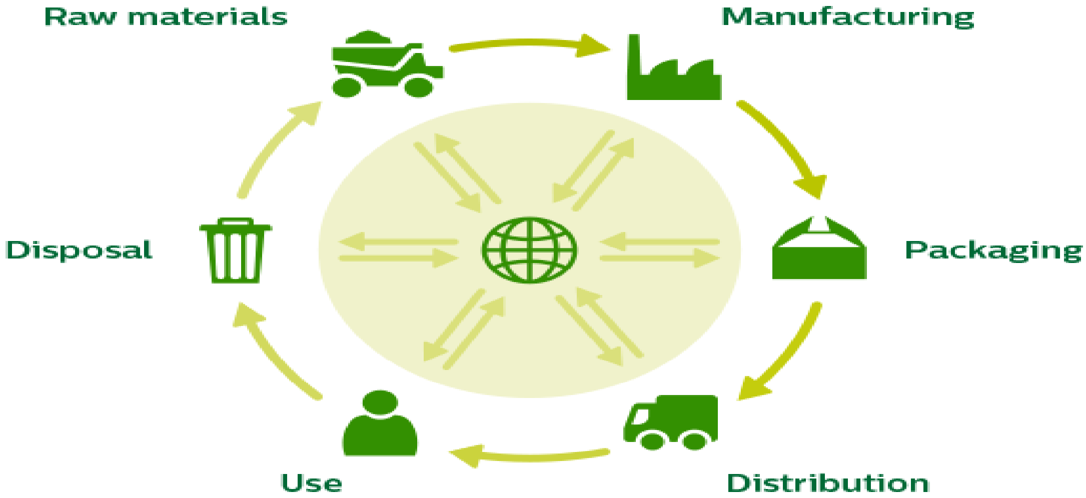


Fig 1.14 – Product Life Cycle Illustration

By examining the product or service over its entire life cycle, informed decisions can be made to avoid transferring pollution from one life stage to another or from one media (air/water/soil) to another. Although carbon emissions and carbon foot printing are very important aspects of life cycle studies, carbon is just one of many elements evaluated within an LCA.

Definition from the International Standards Organization (ISO)"LCA is the compilation and evaluation of the inputs and outputs and the potential impacts of a product system throughout its life cycle".

ISO has developed standards for LCA under the ISO 14040 family of international standards, notably ISO 14040:2006: Principles and framework of LCA and ISO 14044:2006: Requirements and guidelines for LCA standards. These define the methods for developing and verifying LCAs. It is recommended that any LCA be performed according to ISO 14040 standards.

LCAs follow four fundamental steps

- Goal and scope definition
- Inventory analysis
- Impact assessment

- Interpretation

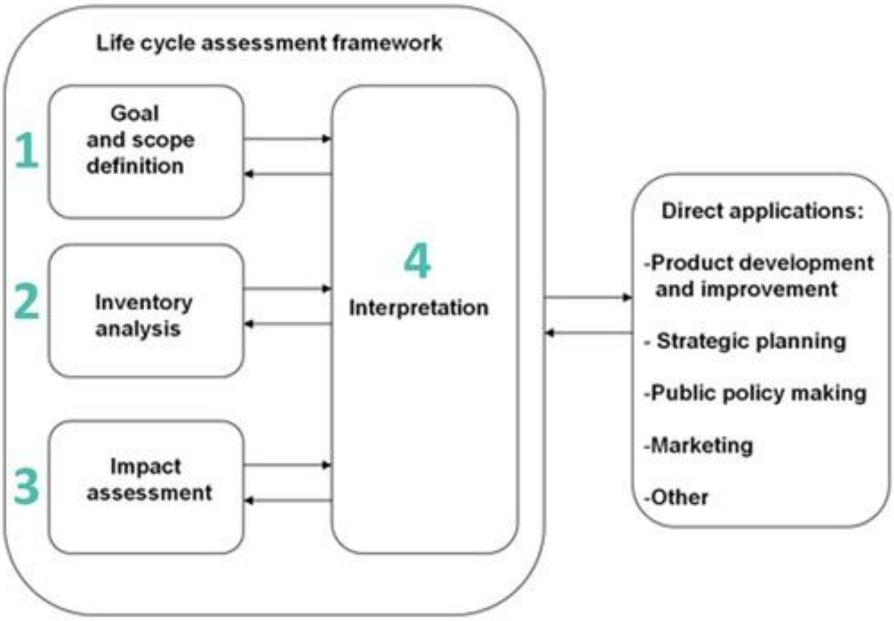


Fig 1.15 – LCA Framework

LCA Limitations: LCA provides many benefits, however it is important to understand its limitations if it is to be used effectively. Knowing these limitations is key to determining whether it is the most appropriate tool for a given situation.

- The results of an LCA are relevant for the geographic area where the data is collected. For example, an LCA conducted on an energy-intensive product in a region where electricity is mainly from hydroelectricity cannot be applied to the same product produced in another region where the electricity is mainly from fossil fuels, unless the LCA calculations are adjusted accordingly.
- Inventories of the inputs and outputs are collected based on where they occur, and then are translated into environmental impacts on a global or regional scale. The results from an LCA identify potential impacts on the environment and are not a calculation of actual impacts. Therefore LCA cannot replace local studies such as ecosystem-based studies of forest dynamics and biodiversity.
- LCA is a steady-state approach. It is a snapshot at a point in time and does not capture changes over time. However, LCA practitioners are actively studying ways to address this issue
- LCA is quantitative and generates many numbers, all of which need to be interpreted. It does not provide a pass or fail result.

- LCA is a risk management tool that supports the identification of the largest impacts and can provide a basis of comparison over time. Improvements will result from the quality of the subsequent decisions.
- LCA is an environmental accounting tool with an inherent level of uncertainty and it should not be seen as having the same level of precision as financial accounting. LCA requires a very large amount of data, particularly to calculate all the inputs and outputs for every step. Databases are often used since it is impractical to collect all the necessary data from original sources (e.g. cannot get data from all the specific power plants from which electricity was sourced). Databases are improving, but practitioners need to understand all the assumptions, the age of the data, etc., and this may not be possible for every data point. There are numerous assumptions made during the assessment. For example, practitioners have to make assumptions about how to allocate electricity used in a plant which produces multiple products on the same equipment. Additionally, turning the inputs and outputs into their impacts on the environment is not an exact science and there are several credible methodologies that are used for impact assessment.
- The results of two LCAs on a same subject may differ according to the objectives, processes, quality of the data, assumptions and the impact assessment methods used. This makes transparency in LCA reporting a crucial element for communication and is the reason why ISO standards require it.
- Conducting an LCA is very resource-intensive, requiring personnel with the necessary expertise, access to data and databases as well as specialized software.
- LCA typically does not address the economic or social aspects of a product, however the life cycle approach and methodologies described in the ISO standards could be applied to these aspects.

Understanding LCA's limitations upfront during the planning phase will help to ensure that the goals of the assessment are achieved or determine whether other life cycle approaches would be more appropriate. Understanding LCA's limitations along with its benefits will also improve understanding of LCAs presented by others.

LCA 101

[xxix]According to the ISO standards, there are four steps in an LCA:

- Goal and scope definition
- Inventory analysis
- Impact assessment

- Interpretation of the results

Goal and Scope: The first question to consider is: why is the organization considering carrying out an LCA?

- This question is not explicitly addressed in the Standards, but experience suggests that this will help define the level of assessment required. For example
- A screening LCA can help identify the most significant contributors to environmental impacts, which can be then used to narrow the focus for further study.
- A full LCA can contribute to supporting marketing claims about a specific product or support an eco-design approach (e.g. supporting product development that aims to develop a new product that minimizes the environmental impacts).

Goal

In order to use LCA effectively, it is important to define the specific goals of the assessment. For example "As part of the organization's continuous environmental performance improvement efforts, technical teams have developed new processes that should reduce the products' impacts on the environment. The organization now wishes to quantify the perceived potential improvement and establish whether there are still other opportunities that could be exploited to optimize the environmental performance of the product." Organizations also need to specify for whom the LCA results are intended and whether they intend to communicate the results publicly.

Functional Unit

Once goals have been defined, the next step is to evaluate what the product does for the user. The objective is to define a "functional unit," or the service performed by the product. It must be measurable and in line with the objectives of the study. It should not be too specific to one product, but rather applicable to other products performing similar functions. The choice of the functional unit is fundamental because it serves as the reference point against which all impacts will be assessed.

- If an LCA's goal is to input into an environmental improvement plan, and the functional unit is well defined, then the product or process can be redesigned to minimize the environmental impact while retaining the required performance.
- A comparative LCA can only be used to compare products that use the same definition of the functional unit.

Examples of functional units for paper industry

- An LCA was recently carried out to measure the potential environmental benefit of thin papers. The underlying premise is that thin papers provide a surface with certain properties for printing books, while requiring fewer resources than regular paper types. However, the processes and resources for producing thin papers differ from those used for traditional paper. Therefore the functional unit was defined as supplying 1m.sq of a printed book (or a certain number of pages) with specified minimum paper properties.

- For a study that compares concrete and wood-framed buildings, the functional unit chosen would be the residential service provided by a multi-storey apartment building over its lifespan. It would not be appropriate to define the functional unit as a certain mass or volume of wood or concrete in this case since different amounts of each are required to fill the function of providing housing.

Scope

The boundary conditions describe the life cycle stages and processes within each that are included or excluded in the scope of the LCA. This means that the steps of the life cycle included must be listed, as well as how relevant upstream and downstream phases are taken into account. Life cycle stages and/or processes may be excluded because of a deliberate decision to narrow the focus on certain elements, a lack of relevance for the study goals, a lack of data, or because of other factors. Studies with different boundaries cannot be compared unless the studies can be adjusted to match definitions of what is included and not included. For example, in most building or construction studies, the systems studied exclude the construction of the infrastructure (e.g. new roads), as well as the manufacturing of machines and tools. This is a typical cradle to-gate system boundary from a study by the Consortium for Resources on Renewable Industrial Materials (CORRIM) showing the three steps that were included.

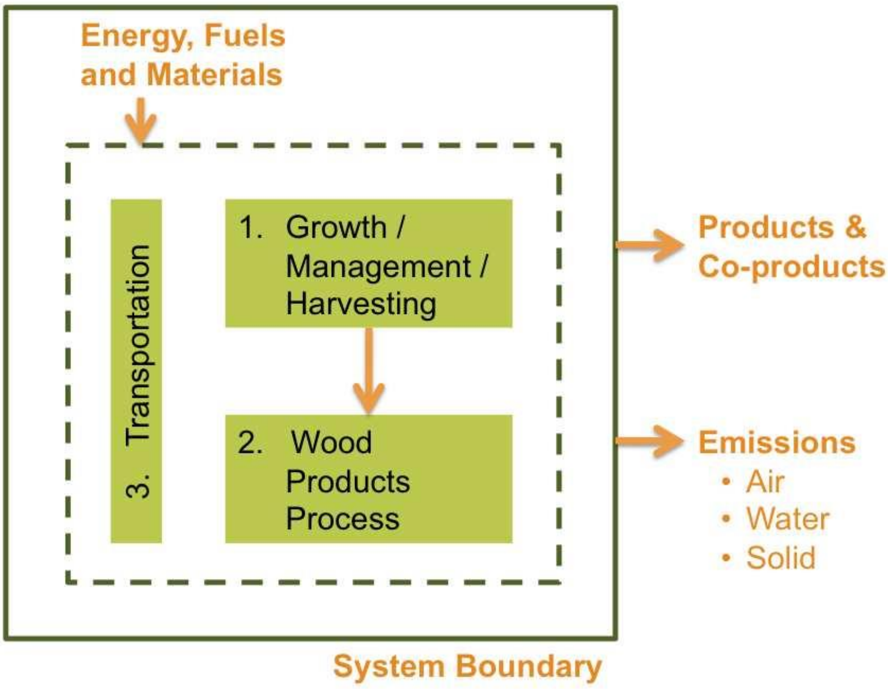


Fig 1.16- Scope of LCA

Data Collection

LCA is an assessment tool that requires a large amount of data and data analysis. Wherever possible LCA practitioners use existing data contained in databases rather than create new data. There are public Life Cycle Inventory (LCI) databases, which are typically free, and private databases that typically charge fees. The quality of the data in the databases varies both within and between databases. The potential impact on the results is often studied by sensitivity analyses on the key inputs and outputs. An organization may need to launch its own data collection process (primary data collection) and involve its suppliers, depending on the data availability, the level of detail required, how current and accurate existing data is and the sensitivity of the results to data variability.

For example, for paper produced in non-integrated mills (i.e. paper mills without pulping facilities), it is advisable to involve the mill's pulp suppliers in the data collection process, as this life cycle step will contribute significantly to environmental impacts. Data collection is an iterative process, which can take up to several months per project. It requires dedicated resources to prepare questionnaires, explain questions and send reminders to relevant contacts, etc. Additionally, consolidation and consistency checks of data are crucial to ensure data integrity and quality.

Modelling

Once all the data is collected for each process step, the data is entered into either dedicated LCA software packages (e.g. TEAM 12, GaBi, SimaPro, etc.) or a simplified Excel sheet. The computer model is set up allow for the calculation of environmental flows of inputs and outputs and categorize them into impact categories.

Inventory Analysis

Inventory analysis is the compilation and quantification of all the inputs and outputs for the chosen system boundary as shown in the diagram below from the National Council for Air and Stream Improvement (NCASI). Inputs include all the raw materials and energy. Outputs include emissions to air (e.g. carbon dioxide), water (e.g. phosphates) and soil (e.g. heavy metals) and any other releases.

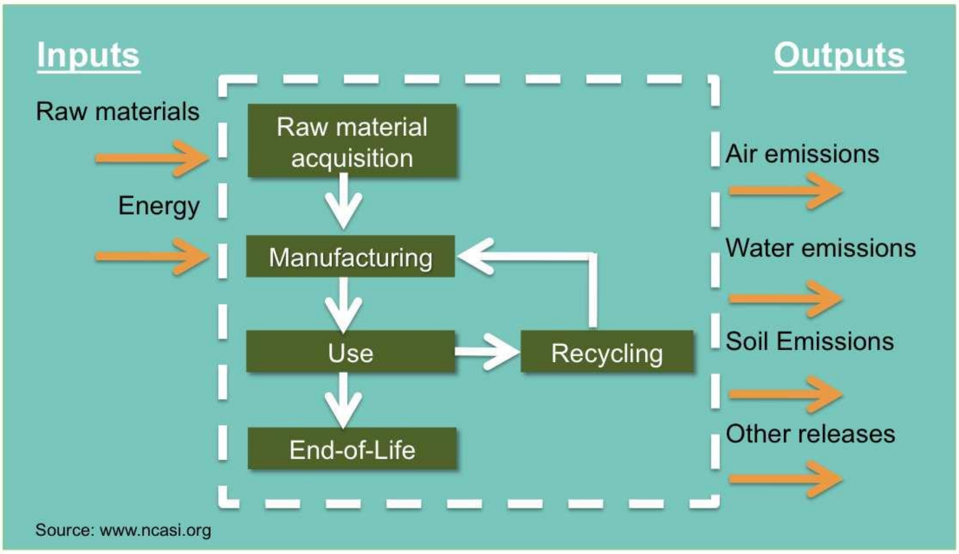


Fig 1.17 – Inventory Analysis

Impact Assessment

Knowing that there are certain amounts of pollutants discharged is not enough for an LCA. Once the environmental flows (from the input and output data) have been identified and measured, they are categorized into impact categories.

Typical impact indicators include a biotic depletion, acidification, climate change, human toxicity, ecological toxicity, eutrophication, fossil fuel depletion, photo oxidant smog formation and stratospheric. Ozone depletion. LCA practitioners and scientific experts, such as the Intergovernmental Panel on Climate Change (IPCC) or the World Health Organization (WHO), have developed methodologies to translate the inputs and outputs into these potential environmental impacts.

There are two types of Impact Categories: Endpoints and Midpoints. An endpoint category seeks to represent the resulting damage to the environment or human health. A midpoint category (e.g. smog formation) aims to cover an environmental problem that stands somewhere between the inventory (i.e. an emission) and an endpoint result. The evaluation of the impact follows a cause effect chain from the inventory flows to at least midpoint indicators, and optionally continuing with further cause-effect modeling to assess endpoint results.

Impact categories that are not easily characterized in LCA include land use impacts and contained toxics (methods for assessing emitted toxics are still being developed). When relevant to the products studied, in addition to the impact indicator values, LCA reports may also highlight life cycle inventory (LCI) data, including consumption of water, wood, minerals, metals and energy.

Interpretation of Results

Once the impacts have been calculated, results can be interpreted in order to fulfill the study objectives. Overall assessment may include reviewing which life cycle stages contribute the most towards each impact category.

For example, if one of the goals was to improve the environmental performance of a product, and if a waste reduction method was chosen, the LCA results could be studied to identify the main sources of waste (e.g. waste generated during a certain step of the manufacturing process, or the production of a certain raw material, etc.) and help the organization design effective solutions to reduce these waste sources.

Example of the Wood, Pulp and Paper Industry – Environmental Flows and Impacts

The following criteria are usually used to characterize the environmental performance of forest products

- Water releases: eutrophication (BOD, COD, Phosphorus, Sulphur), environmental effects monitoring, toxicity (notably for monitoring effects of chlorine and bleaching), etc.
- Air emissions: air acidification (emissions of NOx and SO), greenhouse gases and particulate emissions
- Primary energy consumption, distinguishing renewable and non-renewable energy sources. This is increasingly important as a large number of Canadian forest products companies have converted to using renewable biomass for the majority of their energy needs, rather than fossil fuels.
- Resources depletion: including tracing of wood flows, depletion of non-renewable energy sources and, depending on the product studied, depletion of certain rare materials.

For wood products, additional areas of interest include the use of surface treatments, VOC content and/or emissions in product and packaging use, recycling and waste phases, etc. However, the selection of indicators depends on the type of product studied. For example, if there is a printing phase, the emissions of photo-oxidants may be an additional impact to be studied.

The table below is a synthesis of several LCAs of paper products carried out by PricewaterhouseCoopers. It shows the different life cycle steps considered, from production of raw materials through to end of life. The level of contribution of each life cycle stage varies depending on the impact considered. Results can vary significantly depending on the specific attributes of the product and processes. For each step, the table charts the level of contribution to relevant environmental impacts (high, medium, minor and negligible):

		Life Cycle Stage						
Medium	**Indicator**	Paper Production	Paper Printing	Lamination	Production of other raw materials	Manufacturing	Transport	End-of-life
Energy	Total primary energy consumption	+++		+	++	++	++	
	Non renewable energy	++			++	++	++	
	Renewable energy	+++			+	+		
Air	Greenhouse gas emissions	+++			++	++	++	+
	Air acidification	+++			+	++	++	
	Chemical photo-oxidants	++	+++	+++	++	++	++	+
Water	Human toxicity	+++	+++	+++	+	++	++	
	Ecotoxicity	+++	++	++	+	+	+	
	Consumption	+++			+	++		
	Eutrophication	+++			++	++		
Resources	Non renewable resource depletion	++		+	++	++	++	
Waste	Non hazardous waste production	+++	++		+	++		++

Legend: high (+++); medium (++); low (+); negligible (blank)

Source: PricewaterhouseCoopers

Fig 1.18 – Environmental Flows and Impacts

Tools and Software for LCA

LCA is a data intensive and analytical process. Several tolls and software have been developed in the recent years, here are few: Gabi, Umberto, SimaPro, Gemis, OpenLCA, e-DEA, Ecodesign Studio, Key parameter model, SENSE tool, Clean CO2, Toovalu, and Ecodesign+. Each of the tools and software are designed with specific features and for some for specific industries. Read more about each of the tools that best fit the project needs.

1.5 Zero Waste Strategy

Cities and businesses are increasingly adopting an anti-garbage strategy known as zero waste. Zero waste is a goal that aims to minimize the amount of materials and resources consumed, in an effort to conserve water and energy and ultimately to mitigate climate change. Many motivations drive zero waste initiatives. For cities, a zero waste goal offers an opportunity to reduce the amount of waste going to landfill and provides a framework for reducing greenhouse gas emissions. By pursuing zero waste, cities may begin to fundamentally shift the way citizens think about waste from garbage, or something to be discarded, to a potential valuable resource. Businesses also embrace zero waste initiatives for many reasons. Waste disposal costs are becoming increasingly expensive. Moreover, businesses perceive that customers are interested in purchasing products from organizations that exhibit environmental stewardship. Finally, businesses want to get ahead of regulations that ultimately may make them responsible for the waste that they generate.

What does Zero Waste mean?

Zero Waste refers to waste management and planning approaches which emphasize waste prevention as opposed to end-of-pipe waste management. It is a whole systems approach that aims for a massive change in the way materials flow through society, resulting in no waste. Zero waste encompasses more than eliminating waste through recycling and reuse, it focuses on restructuring production and distribution systems to reduce waste. Zero waste is more of a goal or ideal rather than a hard target. Zero Waste provides guiding principles for continually working towards eliminating wastes.

[xxx]Zero Waste is a philosophy that encourages the redesign of resource life cycles so that all products are reused. The goal is for no trash to be sent to landfills, incinerators, or the ocean. The process recommended is one similar to the way that resources are reused in nature.
Definition - Zero Waste The conservation of all resources by means of responsible production, consumption, reuse, and recovery of all products, packaging, and materials, without burning them, and without discharges to land, water, or air that threaten the environment or human health.

It redesigns our systems and resource use—from product design to disposal—to prevent wasteful and polluting practices that lead to waste. It then captures discards and uses them, instead of natural resources, to make new products, creating far less pollution and feeding the local economy.

Zero Waste Strategies

Source Separation
[xxxi]The separation of materials at the point of collection results in a more homogenous and higher quality waste stream. Source separated material streams are less contaminated by other materials, and are easier and less costly for recyclers to recover. Therefore, source separated materials represent a higher value to recycling markets. Moreover, source separation may improve the environmental performance and economic efficiencies of waste treatment options.

Source separation is particularly important when high product quality is required, or when mechanical separation is difficult and costly. For example, organic waste (garden and food waste) produces valuable products like compost and mulch. Source separated organic waste results in a high quality and high value product, whereas organic waste contaminated by other waste streams, such as glass or plastic, produces a lower quality product that has more limited applications, or may even be sent to landfill. Residual waste generally refers to material that is left over after processing (through a processing facility and/or a source separation system), and which would otherwise be sent to landfill. By improving the quality of materials collected for recovery, thereby increasing recovery rates, source separation can reduce the volume of residual waste to landfill.

Source separation can also play an important role in behaviour change. Householders or businesses that separate waste before disposal can increase their awareness of waste materials and recycling processes. This may affect consumer decisions by encouraging waste avoidance and selecting of products that offer better opportunities for recycling.

Source Separation – Role of Authorities: The Waste Management Authority strongly supports source separation of waste streams wherever reasonably technically, environmentally and economically practicable.

Fig 1.19 – Dry and Wet Waste Separation at Source – GHMC, Hyderabad

The role of Waste Management Authority

Recognise that source separation provides more homogenous and higher value waste streams, allowing for better resource recovery Recognise that source separation reduces contamination of waste streams. Recognise that source separation can support the diversion of waste from landfill Considers the broader application of source separation of waste to be best practice for improving resource recovery and reducing the volume of residual waste Believes source separation supports achieving Waste Strategy targets and outcomes Considers source separation to be consistent with the waste hierarchy Consider source separation favourably in its decision making.

Waste Collection Strategies

There are numerous strategies to help make the future of waste collection system successful, including reducing the frequency of collection, implementing dual collection of solid waste and recyclables, and automating collection practices. Regardless of the strategy judicious implementation is the key for streamlining waste collection systems.

Collection costs typically represent between 40 and 60 percent of a community's solid waste management system costs, so even small changes in collection programs can yield big results. In addition, one can also might realize intangible benefits such as increased customer satisfaction and employee morale.

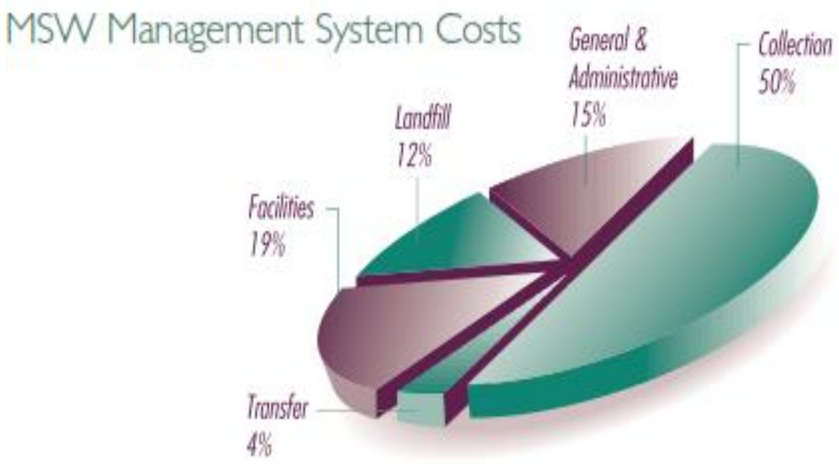


Fig 1.20 – MSW Systems Cost

Reducing Collection Frequency

The growing trend, even in the hottest climates, is to reduce frequency municipal solid waste (MSW) collection day or replace the one of the collection day with a recyclables or yard-trimmings collection. When it comes to picking up municipal solid waste (MSW) and recyclables, less is often best. Offering collection services less often can, in many cases, decrease costs and increase the amount of waste diverted from disposal. Although daily pickup is still popular in many parts of the country, more and more communities globally are successfully making the change to weekly pickup.

Automating Collection

Automated and semi-automated collection vehicles improve efficiency and reduce costs. Both vehicle types reduce labor demand and reduce the risk of worker injury.Once hailed as "tomorrow's key to improving collection efficiency," automation is today's solution to making collection more cost-effective. Traditionally, collecting MSW is a labour-intensive business, often requiring as many as two or three workers per vehicle to lift and dump disposal containers. With the advent of automated lifting systems, however, collection requires fewer workers, thereby reducing labor costs and workers' compensation claims.

Decreasing Fleet Size with Dual Collection

Dual collection systems reduce total fleet and labor costs by decreasing the number of special vehicles needed to provide multiple collection services.Imagine sending four trucks through a neighborhood each week to pick up MSW, recyclables, yard-trimmings, and bulky items. Sound excessive? Multiple passes are the reality for many communities where residents expect a variety of collection services. Rather than maintain separate vehicle fleets, several local governments turned to dual collection vehicles that allow for the collection of separated waste streams in a single vehicle in a single pass.

Increasing Employee Productivity

Local governments and private haulers that employ new management techniques, such as revised organizational structures, updated pay and incentive programs, new training initiatives, modified performance appraisal systems, and new job descriptions, note improved employee morale and rising productivity.

Automated trucks and altered collection schedules only go so far in improving collection efficiency. Efficient collection programs also need a motivated, productive work force. To increase worker productivity, many local governments implement special pay structures, offer better training programs, and reward employees for safe work practices.

Contracting and Competition

A well-designed competitive procurement is the key to obtaining the most reasonable rates and highest quality service. Even when collection has traditionally been provided by the public sector, competition is proving effective. Some jurisdictions use privatization to get the most cost-effective system. Other communities allow private haulers to compete with public crews for the right to provide collection services, which can result in public sector innovation, lower costs, and higher quality. Privatization increases the cost-effectiveness of many public programs. Faced with consumer demand for cheaper and better service, many municipalities outsource the collection of solid waste and recyclables. When privatizing, a well-designed and carefully managed contract is the key to getting reasonable rates and high-quality service.

Waste Hierarchy

[xxxii]Waste hierarchy is a tool used in the evaluation of processes that protect the environment alongside resource and energy consumption to most favourable to least favourable actions. The hierarchy establishes preferred program priorities based on sustainability. To be sustainable, waste management cannot be solved only with technical end-of-pipe solutions and an integrated approach is necessary.

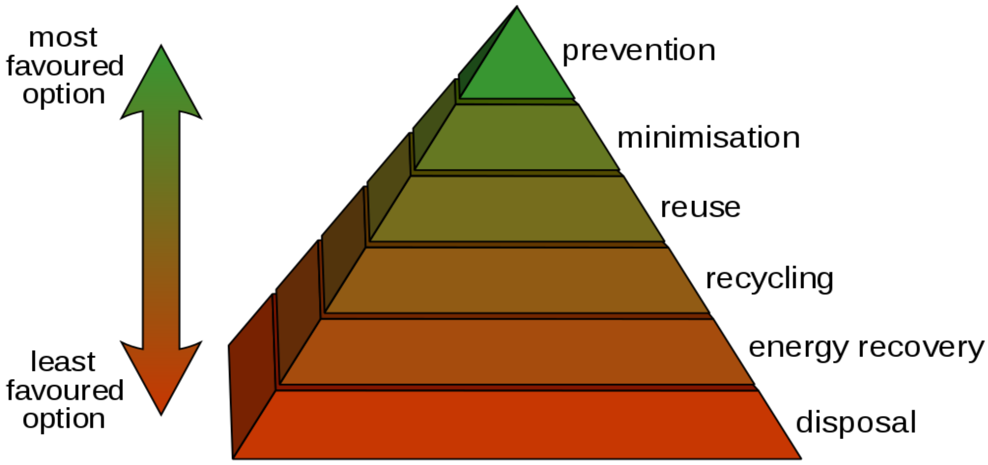


Fig 1.21 – Waste Hierarchy

The waste management hierarchy indicates an order of preference for action to reduce and manage waste, and is usually presented diagrammatically in the form of a pyramid. The hierarchy captures the progression of a material or product through successive stages of waste management, and represents the latter part of the life-cycle for each product.

[xxxiii]The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The proper application of the waste hierarchy can have several benefits. It can help prevent emissions of greenhouse gases, reduces pollutants, save energy, conserves resources, create jobs and stimulate the development of green technologies. The task of implementing the waste hierarchy in waste management practices within a country may be delegated to the different levels of government (national, regional, local) and to other possible factors including industry, private companies and households. Local and regional authorities can be particularly challenged by the following issues when applying the waste hierarchy approach.

[xxxiv]A coherent waste management strategy must be set up Separate collection and sorting systems for many different waste streams need to be established.

- Adequate treatment and disposal facilities must be established.
- An effective horizontal co-operation between local authorities and municipalities and a vertical co-operation between the different levels of government, local to regional and when beneficial, also at the national level need to established
- Finding financing for the establishing or upgrading of expensive sustainable waste management infrastructure to address the needs of managing waste

- A lack of data available on waste management strategies must be overcome and monitoring requirements must be met to implement the waste programs
- The enforcement and control of business plans and practices be established and applied to maximize benefits to the environment and human health
- A lack of administrative capacity at the regional and local level. The lack of finances, information, and technical expertise must be overcome for effective implementation and success of the waste management policies.

From a Cradle-to-Grave Model towards Cradle-to-Cradle Model

Cradle-to-grave is a term used to describe a linear model for materials that begins with resource extraction, moves to product manufacturing, and, ends by a ‘grave’, where the product is disposed of in a landfill. Cradle-to-grave is in direct contrast to cradle-to-cradle. Cradle-to-cradle is a term used in life-cycle analysis to describe a material or product that is recycled into a new product at the end of its life, so that ultimately there is no waste.

[xxxv]Cradle-to-cradle focuses on designing industrial systems so that materials flow in closed-loop cycles which mean that waste is minimized, and waste products can be recycled and reused. Cradle-to-cradle simply goes beyond dealing with issues of waste after it has been created, by addressing problems at the source and by re-defining problems by focusing on design. The cradle-to-cradle model is sustainable and considerate of life and future generations.

The cradle-to-cradle framework has evolved steadily from theory to practice. In the industrial sector, it is creating a new notion of materials and material flows. Just as in the natural world, in which one organism’s ‘waste’, cycles through an ecosystem to provide nourishment for other living things, cradle-to-cradle materials circulate in closed-loop cycles, providing nutrients for nature or industry.

An example of a closed loop, cradle-to-cradle product design is DesignTex Fabric. It has designed an upholstery fabric, Climate Lifecycle, which is a blend of pesticide- and residue-free wool and organically grown ramie, dyed and processed entirely with non-toxic chemicals.

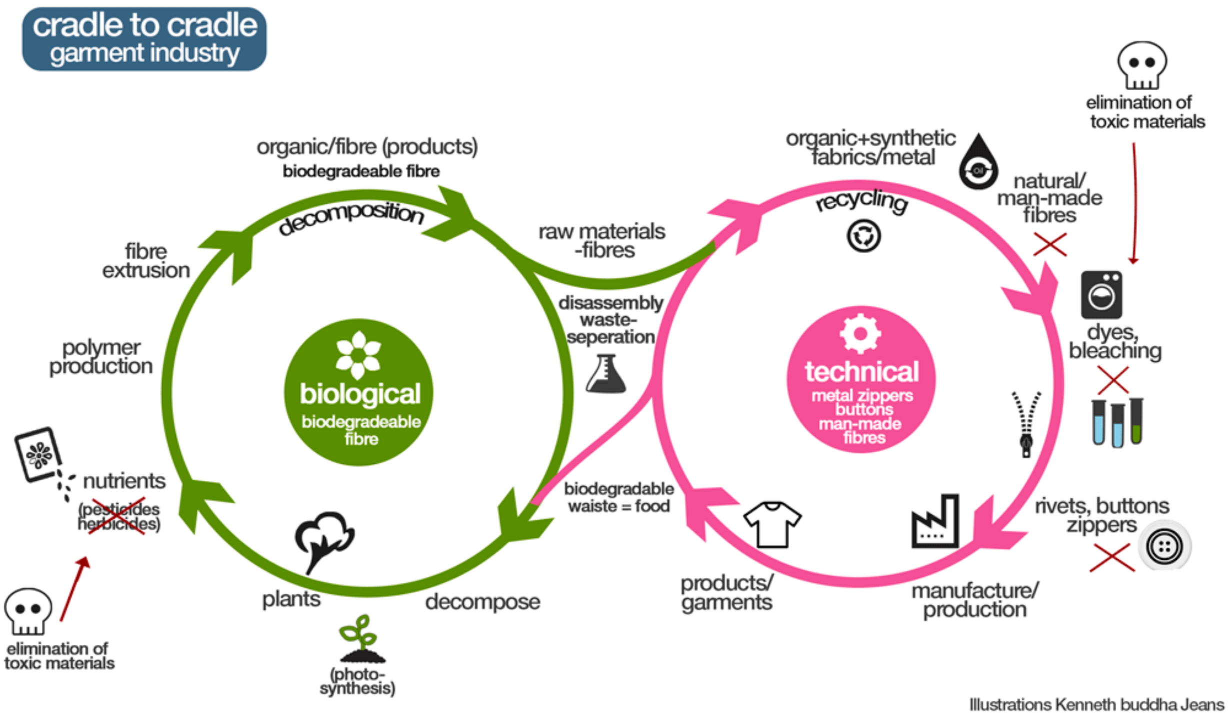


Fig 1.22 – Cradle to Cradle Model

Summary

1. Resource Efficiency ensures process efficiency at every stage of the product life cycle.
2. Resource Efficiency not only improves and enhances product quality but also minimizes waste generation to optimum levels.
3. Minimized waste generation through process efficiency reduces environmental, social, and economic costs of products.
4. Resource Efficiency calls for quality inputs and process efficiency at every stage of the value chain. Thus helps in fixing the responsibilities in the entre value chain.
5. Efficient processes produce socially and environmentally sustainable products; ensuring acceptability and competitive price from local to global markets.
6. Resource Recovery is a perception change of looking at waste as secondary resources.
7. Resource Recovery methods in addition to reducing the amount of waste that needs to be disposed; it also adds to energy and material resources.
8. Improving the value chain for efficient flow of recovered materials and energy is important for viability of Resource Recovery.
9. Reutilization of the secondary resources of one production cycle as primary resource to another production process enhancing inter and intra industrial symbiosis is the foundation of a Circular Economy.

10. Resource Security is ensuring availability of resources for all stakeholders in the society, environment, and future generations.
11. The objective of a LCA is to optimize Resource Efficiency and Recovery Potential at every stage of the value chain in the product life cycle.
12. Managing waste to minimize the impact on environment, society and economy for Sustainable Development of communities is Zero Waste strategy.
13. Resource Efficiency and Recovery approaches paves way in promoting Climate adaptive technologies.

Reading Materials

1. https://archive.epa.gov/epawaste/nonhaz/municipal/web/pdf/k99007.pdf
2. https://www.researchgate.net/publication/26843958_THE_LIFE_CYCLE_ASSESSMEN T_-_A_CASE_STUDY_OF_TRANSPORTING_VOLVO_CARS
3. https://www.e-education.psu.edu/eme807/node/690
4. http://www.no-burn.org/wp-content/uploads/On-the-Road-to-Zero-Waste.pdf

To do Activities

Background

The agriculture sector of India has occupied almost 43 percent of India's geographical area. Agriculture is still the only largest contributor to India's GDP even after a decline in the same in the agriculture share of India. Agriculture also plays a significant role in the growth of socio-economic sector in India.

1. Identify and prepare a model which has scope to incorporate for Circular Economy Model in rural economy.
2. Analyze the waste use efficiency in agriculture sector, in your local area.
3. Identify local knowledge and conventional resource recovery methods in rural production systems.

Chapter2 -Consumerism

Introduction

The post-world war era has witnessed significant change in the mindset of the consumers globally to mass consumption, with advancements in production technologies towards mass production. Advertising played very crucial role in fuelling the economy and creating an appetite in the market for consuming goods produced in huge scales. This paradigm shift in the global consumption and production practice has created environmental, social, and economic imbalances making the modern mass production and consumption model questionable and deemed unsustainable; threatening the survival and development with growing concerns of Climate Change.

Consumption patterns are driven by changes in perception of an affluent lifestyle, manifested through advertising, and media. Growing concerns of resource scarcity, and increasing social and environmental costs of production raised need for changing consumption and production practices to be more sustainable. Growing popularity among consumer and producers for Eco-labelling and green certification of the product value chain vouches for changing consumer behaviour for socially and environmentally responsible production and consumption.

Objective

The objective of this module is to give a perspective into the history and evolution of consumerism globally, how and what policies influenced and changed the consumer behavior in India, the impact of advertising on consumerism, and the causes for growing significance of Eco-Labelling. The material equips the students with the background required to understand consumerism, and how business can strategize production to meet global standards and then wage educated consumers' demands of responsible production and consumption.

2.1 Consumerism

Consumerism is a social and economic order that encourages the acquisition of goods and services in ever-increasing amounts. [xxxvi]With the industrial revolution, but particularly in the 20th century, mass production led to an economic crisis: there was overproduction—the supply of goods would grow beyond consumer demand, and so manufacturers turned to planned obsolescence and advertising to manipulate consumer spending. [xxxvii]In 1899, a book on consumerism published by Thorstein Veblen, called The Theory of the Leisure Class, examined the widespread values and economic institutions emerging along with the widespread "leisure time" in the beginning of the 20th century. In it Veblen "views the activities and spending habits of this leisure class in terms of conspicuous and vicarious consumption and waste. Both are related to the display of status and not to functionality or usefulness."

Definition

[xxxviii]The term Consumerism is of recent vintage. Consumerism is a social movement seeking to augment the rights and powers of buyers in relation to sellers. Consumerism has been defined as "the organised efforts of consumers seeking orders, restitution and remedy for dissatisfaction they have accumulated in the question of their standard of living".

Consumerism is the concept that the marketplace itself is responsible for ensuring social justice through fair economic practices. Consumer protection policies and laws compel manufacturers to make products safe.Consumerism is the theory that a country that consumes goods and services in large quantities will be better off economically.

What is Consumerism?

The term "consumerism" has also been used to refer to something quite different called the consumerists movement, consumer protection or consumer activism, which seeks to protect and inform consumers by requiring such practices as honest packaging and advertising, product guarantees, and improved safety standards.

In this sense it is a movement or a set of policies aimed at regulating the products, services, methods, and standards of manufacturers, sellers, and advertisers in the interests of the buyer.

In economics, consumerism refers to economic policies placing emphasis on consumption. In an abstract sense, it is the consideration that the free choice of consumers should strongly orient the choice what is produced and how, therefore the economic organization of a society (compare producerism, especially in the British sense of the term). Also this vote is not "one man, one voice," but "one dollar, one voice," which may or may not reflect the contribution of people to society.

History of Consumerism

A person who buys goods and services is a consumer. The concept of buying and selling is as old as human civilization. There was a time when goods and services would exchange among people to fulfil their needs; such transactions were known as Barter Transactions. Barter Economy was evident in Stone Age, Bronze Age and Iron Age. With the introduction of „money‟ Barter Economy transformed into monetary economy wherein goods and services were provided in exchange of money or things as valuable as money. In order to become a consumer following conditions needs to be fulfilled –

1. A presence of need to purchase/ A desire to purchase,

2. A presence of power to purchase,

3. Availability of goods/services desired,

4. Willingness of the owner of goods and services to sale in exchange of monetary consideration.

The consumer society emerged in the late seventeenth century and intensified throughout the eighteenth century. While some claim that change was propelled by the growing middle-class who embraced new ideas about luxury consumption and about the growing importance of fashion as an arbiter for purchasing rather than necessity, many critics argue that consumerism was a political and economic necessity for the reproduction of capitalist competition for markets and profits, while others point to the increasing political strength of international working-class organizations during a rapid increase in technological productivity and decline in necessary scarcity as a catalyst to develop a consumer culture based on therapeutic entertainments, home-ownership and debt. The "middle-class" view argues that this revolution encompassed the growth in construction of vast country estates specifically designed to cater for comfort and the increased availability of luxury goods aimed at a growing market. Such luxury goods included sugar, tobacco, tea and coffee; these were increasingly grown on vast plantations (historically by slave labor) in the Caribbean as demand steadily rose. In particular, sugar consumption in Britain during the course of the 18th century increased by a factor of 20.

[xxxix]Critics argue that colonialism did indeed help drive consumerism, but they would place the emphasis on the supply rather than the demand as the motivating factor. An increasing mass of exotic imports as well as domestic manufactures had to be consumed by the same number of people who had been consuming far less than was becoming necessary. Historically, the notion that high levels of consumption of consumer goods is the same thing as achieving success or even freedom did not precede large-scale capitalist production and colonial imports. That idea was produced later, more or less strategically, in order to intensify consumption domestically and to make resistant cultures more flexible to extend its reach.

[xl]Since the 1800s and the Industrial Revolution the world has been consuming at a higher rate than ever. The Revolution allowed products to be available in enormous quantities for the first time in history. Because of their unheard of low cost, products were basically made available to all. This unlimited access led to the era of Mass Consumption. It soon grew to be expected that people have the latest model of the newest appliance. 'Why have the old model? The new one was more efficient'. This philosophy soon morphed into people buying newer models based on appearance rather than function, and consumption continued to grow. Since the 1950s, people everywhere on the globe have consumed more goods than the combined total of people throughout history.

There are five basic stages of the consumer cycle extraction, production, distribution, consumption, and disposal. This is the basis of the material economy.

What powers this cycle?

Planned obsolescence and perceived obsolescence are the main types of production that contribute to the excessive consumerism in America today.

Planned obsolescence: Companies design products so that people will need or want to throw them out soon after they buy them.

Perceived obsolescence: Essentially “keeping up with the Joneses”. Companies use advertisements and gimmicky new models to convince the consumer that they need the new model.

[xli]This pattern was particularly visible in London where the gentry and prosperous merchants took up residence and created a culture of luxury and consumption that was slowly extended across the socio-economic divide. Marketplaces expanded as shopping centres, such as the New Exchange, opened in 1609 by Robert Cecil in the Strand. Shops started to become important as places for Londoners to meet and socialise and became popular destinations alongside the theatre. Restoration London also saw the growth of luxury buildings as advertisements for social position with speculative architects like Nicholas Barbon and Lionel Cranfield.

The great turn in consumerism arrived with the Industrial Revolution. While before the norm had been the scarcity of resources, The Industrial Revolution created an unusual situation: for the first time in history products were available in outstanding quantities, at outstandingly low prices, being thus available to virtually everyone. And so began the era of Mass Consumption, the only era where the concept of consumerism is applicable. It's still good to keep in mind that since consumerism began, various individuals and groups have consciously sought an alternative lifestyle, such as the "simple living," "eco-conscious," and buy local" movements. Consumerism, the promotion of consumer rights and protection. Subject to the doctrine of caveat emptor (Latin, “let the buyer beware”) The older term and concept of "conspicuous consumption" originated at the turn of the 20th century in the writings of sociologist and economist, Thorstein Veblen. The term describes an apparently irrational and confounding form of economic behaviour. Veblen's scathing proposal that this unnecessary consumption is a form of status display is made in darkly humorous observations like the following: "*It is true of dress in even a higher degree than of most other items of consumption, that people will undergo a very considerable degree of privation in the comforts or the necessaries of life in order to afford what is considered a decent amount of wasteful consumption; so that it is by no means an uncommon occurrence, in an inclement climate, for people to go ill clad in order to appear well dressed*." (The Theory of the Leisure Class, 1899).

There was growth in industries like glass making and silk manufacturing, and much pamphleteering of the time was devoted to justifying private vice for luxury goods for the greater public good. This then scandalous line of thought caused great controversy with the publication of Bernard Mandeville's influential work Fable of the Bees in 1714, in which he argued that a country's prosperity ultimately lay in the self-interest of the consumer.

With the growth of affluence and tremendous advances in literacy and science and technology, consumerism has gradually emerged in most of the western countries as a powerful force to reckon with, when the markets are flooded with innumerable varieties of products which are sometimes close substitutes to each other and particularly when there is only slight, if not negligible difference in the design, quality, brand, grade, style, mark, finishing, packaging etc., of the different products but considerable variances in prices, the consumers at large are flabbergasted as to what are the exact factors that contribute towards the price variances of the different products they are purchasing, whether there is any substantial difference at all in the quality, size and ingredients of the various products they consume.

[xlii]Consumerism, that is the organized attempts to fight for better value for money for individual shoppers in the marketplace, has clearly lacked the more obvious radical undercurrents of environmentalism, feminism or the peace movement. Likewise, in its focus on everyday goods, it could never hope to attract the broad attention of the media and the public in the same manner as, for instance, the human rights groups. Consumerism has often been regarded as a transient interest, the abuses of the market place attracting the attention of disgruntled consumers at specific moments in time, yet it remains an interest lacking an ideological or political core which could attract a truly mass base whose commitment could be sustained over a significant period.

But such a view overlooks much of the work of comparative-testing consumer organizations. Magazines such as Test, QueChoisir, Consumer Reports and Which have been usually associated with the urban professional middle classes, as guides to their consuming lives, yet many of the organisations behind them have been involved in a range of political issues which suggest important parallels and similarities to other social movements. Furthermore, the magazines themselves have attracted literally millions of subscribers from all over the world and while such figures are not directly equivalent to the committed donations of members of environmental and human rights organizations, a sizeable minority of consumers have regarded themselves as part of a social movement helping to make the market a safer, fairer and more just place for everybody. The following summary of the modern international consumer movement will demonstrate both the extent to which consumers have been prepared to organize as critics of the marketplace and their commitment to correcting abuses which not only assist the affluent individual but consumers as a whole. It will begin by over viewing the growth of the modern consumer movement in Western Europe and America from the 1930s onwards, before moving on, in the second half of the paper, to highlight certain aspects of the international consumer movement. It will demonstrate the extent to which an essentially western-based comparative testing movement was able to adapt to the consumer concerns of the developing - that is the concerns over access to basic needs - and the ways in which these resulted in a new politics of consumption which came to have a profound influence on the shape and nature of global civil society in the 1980s. What such an examination will demonstrate is the ways in which consumers have sought to act as political agents in the marketplace rather than as the passive recipients of the fruits of economic growth.

Consumerism in India

In order to understand the present cultural changes taking place due to the socio-economic changes in India, it is necessary to understand the predominant thought process, which guided her from the ancient times. xliiiThe growth of the Indian civilization, which traces back to the pre-Vedic ages, right from the existence of the Harappa and Mohenjo-Daro civilisation, itself, indicates the prevalence of a rich cultural tradition, which guided the Indian social life. The coming of the Aryans and their settlement in the Northern plains brought an end to their nomadic life. The Indian economy was predominantly based on agriculture, as a result of which it had a marked influence in shaping the cultural values of her people. Values relating to peace and constructive activity were given greater importance compared to those related to war and destruction. This was in contrast to the western countries, which were influenced by colder and harsher climatic environment and scarcity of resources leading to a development of a materialistic culture where accumulation of resources played a key role. In contrast, economic urges played comparatively smaller role in the evolution of Indian culture. (Husain 1956, reprinted in 1961).

India has witnessed onslaughts of invasion from various parts of the world. It was, however, the advent of the Aryans, which brought in major changes in the socio-economic, religious, cultural and political dimensions. The Vedic Hindu culture, which became the basis of the Indian cultural tradition, was a product of the interplay between the Aryan and the non-Aryan cultures. Later on there was an assimilation of various other streams of thoughts into this Indian tradition, like, the Islamic culture and the European culture; the latter being brought in by the British, Portuguese, French and Dutch invasions. Before the infiltration of the influence of the Western culture, the existing Indian culture (which was influence by Vedic culture as well as Buddhism) was based on the principles of self-restraint, and austerity, lacking in the material gains.

Gandhian Principles on Swaraj, Austerity and Self-Restraint

The rising importance of India in the global system makes one look back into the developments that the sub-continent has undertaken since its inception as a nation after independence.

- Gandhi's perception towards consumption can be viewed from his doctrine on "swadeshi". The essence of the concept lies in the following propositions as pointed by Sharma (2003, ppl65)
- Gandhi being the proponent of self-austerity and restraint, for him, consumers would have the propensity to reduce one's 'wants'. In reducing wants, the utility function will depend on the commodities that are locally made. Meaning thereby that, utility from the imported goods will be kept to a minimum. The reason behind this is that if the utility from the imported item is high, it would lead to a decrease of demand of the local goods which will go against the spirit of swadeshi.

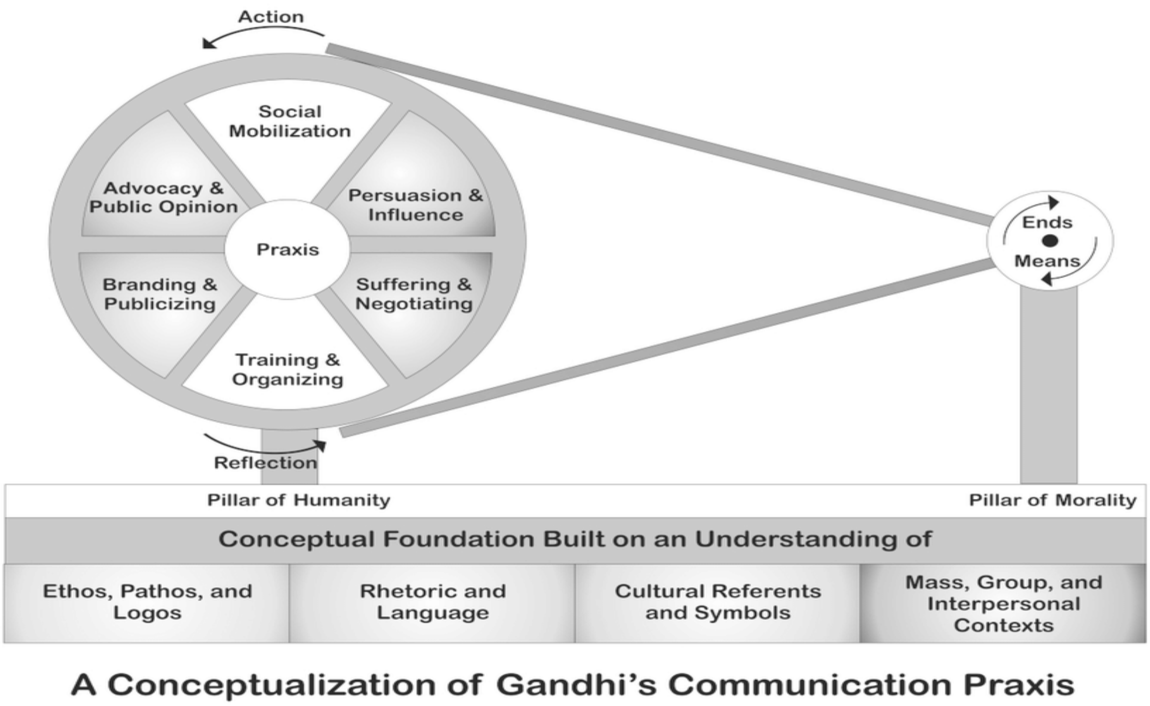


Fig 2.1 Gandhian Praxis Model

Hence following a low utility function of imported goods would advocate a demand for local-made goods and services, provided that the neighbourhood has the ability to make the goods and services. This would result in a cooperative dependence between the consumers and the producers, culminating into cost effective methods. So there would inevitably be an increase in the demand of the localized goods by the consumers, followed by the reduction in the cost of the production due to the production of the items in the localized areas, which reduces the transportation charges. So Gandhi emphasized on the revival of the Indian textile industries, which indirectly brought in economic empowerment of the masses. This was followed by the boycott of the foreign textile, which was to strike at the economic foundation of the British Empire. So swadeshi did not mean buying goods made in India, neither was it only related to the boycott of the foreign products. Swadeshi had a broader meaning, where it required people to give preference of goods made in their neighbourhood rather than some far-away place.

As people failed to grasp this spiritual meaning of swadeshi, hence after independence, swadeshi lost its appeal among the politicians and the masses, as a result of which there resulted in a decline of employment in the villages. This was followed by a pro-industrialisation policy, which was taken up by India during the Nehurvian era. It further extinguished the spirit of swadeshi, which also resulted in extinguishing the age old vision of self-austerity and restraint. Hence after independence, on one hand, one witnessed an increasing acceptance of the western model of development (which is based on technological predominance), while on the other it was followed by a slow waning of the Gandhian ideas of social transformation

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Socio Cultural Evolution of Consumerism in India

In its process of development, India has tried to maintain a balance between tradition and modernity and, thereby, it has tried to inculcate the spirit of modernization within the broader framework of its traditional values, institutions and cultures. The result was not always a smooth process. There were contradictions and conflicts that sometimes led to major conceptual and structural changes, which brought in new socio-economic transformations. Some of these changes are so drastic in nature that they have often created a new watershed in India's history. A brief discussion on India's changing politico-economic scenario shows the digression from the Gandhian and Nehruvian philosophy of nation making. India has witnessed a remarkable development in the economic policies from the age of the 'Nehruvian Socialism' to the present globalised economy. However, this work would not focus on understanding the reasons for the abandoning of the earlier policies in favour of a developmental strategy biased towards the private sector, which survives on market-based allocation of resources. Rather, this work would only be tracing the time path of systematic evolution of the growth pattern from a post-independence regulated production structure to the current privatized, market form of industrialisation. This new industrial policy, which was introduced in 1991, shows a radical shift from the Nehruvian policy and was based on the above principles by taking into account the changing global trends. The Nehruvian policy was based on the development and dependence on the public sector which was supposed to provide a framework for the development of a planned economy. The eradication of poverty and redistribution of wealth were considered the two important goals which could be achieved through this planned economy. .Indeed such a vision of nation building was a necessity, which helped in the development and stabilisation of the basic foundation of the Indian society. We are talking of a country which, at that time, had gained freedom from the colonial rule and was in a situation of great political, economic and social turmoil.

[xliv]In order to understand the 'new' developments that occurred in the socioeconomic conditions of India, a study of the Indian tradition became a necessity. This was due to the fact that the modem social values, on which the developments were based, were the products of the western philosophy which, to a large extent, deviated from the old Indian traditional values. The Indian traditional values have always been in a flux, as from time to time there has been an amalgamation of various cultures and religious philosophies. Indian tradition professes a universal humanist tradition, which has neither been dogmatised by any particular set of beliefs nor has it glorified any particular cultural pattern or lifestyle. In contrast, it has always emphasized on a pluralistic culture which has led to a complete individual fulfillment. Another view advocated by the Indian tradition, is the insistence on the individual's embeddedness within one's own culture rather than inculcating an alien one, which would inevitably lead to a complete fulfillment. Despite the existence of flaws within this tradition, it has managed to survive against the other traditions, which were based on stronger materialistic and militaristic foundations. The resistance to these stronger forces, that has been a historical phenomenon, has gained new dimensions in the recent era. However before discussing these new dimensions, a study of the Indian tradition was a necessity. Let us enumerate a few of the major assumptions of the Indian tradition, which probably serve as the basic foundation in understanding the Indian society. One being, the concept of a harmonic relationship that exists among man, nature and society and the other being, the origin of man from Infinity and his final dissolution into the same. It talks about this final achievement of self-realization of man through his individual means, which is achieved through the process of 'simple living and high thinking'. So as per the traditional Indian institution, cultural and spiritual growth gained predominance over material possessions (Naik 1983). It based its traditional ethos on self-control and restraint, which is in direct contrast to the spirit of modem industrialism65 which dominate the western world. However this age-old Indian traditions underwent radical changes since the advent of the British rule in India.

The British colonial rule influenced the Indian socio-economic and cultural spheres by introducing their own value systems which emphasized on secularization, westernization and modernization (Naik 19-83). The western civilization was based on the blind pursuits of material values, the love of power and the use of the power to exploit the poor. The British incorporated and practiced these values while establishing their authority over the Indians. Thus the old system of Indian values that was based on simplicity of limited wants was replaced by a culture based on consumption - a culture where market expansion became the driving force behind its sustenance. This project of the development of the Indian society under the influence of this new world view, encompassed all areas ranging from the administrative, political, economic, social, cultural, to even religious areas. What transpired was a radical change in the structure of the Indian society, which was based on western values. However with the rise of the national freedom movement, this process of development came under serious attack from the Indian nationalists, who found these developments to be evils of colonialism they believed, any development of the Indian society was a myth, till there was complete freedom from the colonial rule. As a result, they envisaged various developmental strategies, that were based on indigenous ideas and those borrowed from the western societies. There existed differences of opinions regarding the implementations of the appropriate development strategy, as leaders were divided in their views on this issue. Among the various views which existed, three prominent views came up on which the Indian leaders constructed their models of development. Interestingly, among these three models, the one which gained predominance over the others, was that which was based on western philosophy of consumerism. As per this western philosophy of life, consumerism helped in the attainment of a better lifestyle which was gained through scientific and technological developments and consequently, through the capitalistic mode of production. In contrast to this viewpoint, there were those leaders who talked of a similar theory of unlimited human needs and the use of science and technology to satisfy them, but negated the capitalist mode of production.

In our country, the basic reasons for the emergence of consumerism have been quite different to those of western countries as listed below.

- There was an acute dearth in essential consumer goods and the inflation in 1973-74 caused the emergence of consumer movement.
- Indian industry did not attain advancement in technology to produce the wide range of alternative products.
- The Indian house wife tends to be a more discriminating and inactive customer than her western counterpart because she has hardly any money or insignificant money for her wilful spending and she has no much time to compare and decide on her purchases.
- Indian consumers were supplied inferior quality of goods.
- They were provided with health hazardous products causing harm to mankind resulting in serious sickness.
- Indian consumers were exploited by misguiding advertisements containing false

information.

- There was artificial scarcity of essential goods by hoarding and black-marketing.
- There was a lack of efficient after sale services.
- The improper attitude of sellers especially at rationing shops for sale of goods at government controlled prices also paved the way for resurgence of commercialism in India.

The Indian consumer movement thrusts on the availability quality and pricing of essential goods. In our country major segment of the consumer has to spend cautiously and tries to keep balance between income and expenditure owing to the limited income and the low standard of living. This calls for and the dire need to protect consumer as he is the nerve center in the economic activity.

2.2 The Influence of Advertising on Consumption

Almost every one grows up in the world which is flooded with the mass media e.g. television, advertising, films, videos, billboards, magazines, movies, music, newspaper, and internet. Of all marketing weapons, advertising is renowned for its long lasting impact on viewer's mind, as its exposure is much broader. Advertising is a subset of promotion mix which is one of the 4P's in the marketing mix i.e. product, price, place and promotion. As a promotional strategy, advertising serves as a major tool in creating product awareness in the mind of a potential consumer to take eventual purchase decision. Advertising, sales promotion and public relations are mass-communication tools available to marketers. Advertising through all mediums influence audiences, but television is one of the strongest medium of advertising and due to its mass reach; it can influence not only the individual's attitude, behavior, life style, exposure and in the long run, even the culture of the country.

[xlv]The evolution of advertisement dates back into the ancient times. Societies used symbols, and pictorial signs to attract their product users. Over centuries, these elements were used for promotion of products. In the early ages, these were handmade and were produced at limited scale for promotions. Later on, this phenomenon gained strength more intensively for promotional purposes. Today's modern environment, advertisements have become one of the major sources of communicational tool between the manufacturer and the user of the products.

The major aim of advertising is to impact on buying behavior; however, this impact about brand is changed or strengthened frequently in people's memories. Memories about the brand consist of those associations that are related to brand name in consumer mind. These brand cognition influence consideration, evaluation, and finally purchases. The principal aim of consumer behavior analysis is to explain why consumers act in particular ways under certain circumstances. It tries to determine the factors that influence consumer behavior, especially the economic, social and psychological aspects. When young people choose advertising information and characters as their role models, they may not only identify with them but also intend to copy them in terms of how they dress and what they are going to buy.

[xlvi]The subject of consumerism goes beyond business ethics to include every aspect of economic life and then further to cultural studies, political science, and philosophy. Staying within business ethics, however, and specifically with advertising, the subject of consumerism provokes the question of '*Does advertising create desires (and is there anything wrong with that)?*'

Television commercials lead to need creation where it does not previously exist and force the viewers to buy products they do not really need (Richins, 1995; Mayne, 2000). How do we decide, however, what we want—and even what we want desperately—when we don't truly need anything anymore? One answer is that we create needs for ourselves. All of us have had this experience. For our entire lives we lived without iPhones (or even without cell phones), but now, somehow, getting halfway to work or campus and discovering we left our phone at home causes a nervous breakdown.

Advertising plays a role in this need creation. Take the Old Spice body wash ad. Body wash as a personal grooming product was virtually unheard of in the United States until only a few decades. More, as a product with specific characteristics, it's hard to see how it marks an advance over old-fashioned soap. This absence of obvious, practical worth at least partially explains why the Old Spice ad provides very little information about the product and nothing by way of comparison with other, similar options (like soap). Still, the Old Spice body wash is a hit. The exact techniques the ad uses are a matter for psychologists, but as the sales numbers show, the thirty-second reel first shown during the Super Bowl has herded a lot of guys into the idea that they need to have it.

The push of advertising into everything is a proxy for a larger question about the difference between business life and life. It could be that, at bottom, there is no difference. We are Homo economicus. The anti-romanticists were right all along love can be bought with money, fulfillment is about consuming, and that bumper sticker "He who dies with the most toys wins" is true.

Key Takeaway

- Consumerism places our entire life within the context of consumer goods and services.
- Advertising can create desires.

- Advertising creating desires raises questions about whether ads violate consumers' dignity and rights.
- The knowledge and financial power of companies (and their ad agencies) may also be an obligation for restraint.
- Children are especially vulnerable to sophisticated advertising and may require special protections.
- Discussion of the advertising that creates needs is a proxy for a larger discussion about the role of money and consumption in our lives.

Impact of Advertising on Consumerism

The modern society of consumerism and rampant development' is destroying our world. The biggest problem with consumerism is the fact that people do not realize that there is a problem. We are already consuming resources at an alarming rate and quicker than our planet is able to replenish. If we focus on Western countries where the culture is the most developed, the problem is even greater. It has been estimated that if everyone on earth consumed the same amount as the average US citizen four planet earths would be needed to sustain us. The story gets worse with even wealthier countries, with an estimated 5.4 planet earths needed to sustain us if we all lived at the same standard as the United Arab Emirates.

Effects of Consumerism on Society

The huge rise in resource consumption in wealthier countries has led to an ever widening gap between the rich and the poor. As the age old saying goes, "the rich get richer and the poor get poorer."

Using the latest data, in 2005, 59 percent of the world resources were consumed by the wealthiest ten percent of the population. Conversely, the poorest ten percent accounted for just 0.5 percent of resource utilization. Building on this, we could look at the trends in spending, and where this money could be better used. It has been estimated that just US$6 billion would provide basic education worldwide. Another $22 billion would give every person on the planet access to clean water, basic health services, and sufficient nutrition.

Now, if we look at some areas of spending, we can see that our society has serious problems. It is estimated that every year, Europeans spend $11 billion on ice cream – yes, ice cream! This is nearly enough to bring education to every child on the planet. Building on this figure, around $50 billion is spent on cigarettes in Europe alone, and around $400 billion is spent on narcotic drugs around the world. Research shows a close link between the rise of the modern culture of consumerism and the worrying rates of obesity we are seeing around the world. However, this should come as no surprise, since consumerism implies exactly that – using as much as we can, rather than as much as we need.

This causes a domino effect of problems on society. Over-consuming leads to obesity, which in turn leads to further cultural and social problems. For example, medical services are stretched further and further as the worldwide obesity rates rise. In the USA, per capita medical expenses are said to be around $2,500 more for obese people than for people of a healthy weight.

Effects of Consumerism on Environment

As well as obvious social and economic problems, **consumerism is destroying our environment**. As the demand for goods increases, the need to produce these goods also increases. This leads to more pollutant emissions, increased land-use and deforestation, and accelerated climate change. We are experiencing devastating effects on the planets water supplies, as more and more water stores are used up or diverted as a part of intensive farming procedures.

Waste disposal is becoming a problem worldwide, and our oceans are slowly but surely becoming a giant waste disposal pit. It is estimated that over half of the plastic produced every year is single use – this means that it is used once, and then either thrown into landfill or finds its way into the environment. According to scientists, up to 12 million tons of plastic enters the ocean every year, forming giant floating garbage patches all over the world.

2.3 Consumption Trends

Overconsumption is a situation where resource use has outpaced the sustainable capacity of the ecosystem. A prolonged pattern of overconsumption leads to environmental degradation and the eventual loss of resource bases.

Generally, the discussion of overconsumption parallels that of human overpopulation; that is the more people, the more consumption of raw materials takes place to sustain their lives. But, humanity's overall impact on the planet is affected by many factors besides the raw number of people. Their lifestyle (including overall affluence and resource utilization) and the pollution they generate (including carbon footprint) are equally important. Currently, the inhabitants of the developed nations of the world consume resources at a rate almost 32 times greater than those of the developing world, who make up the majority of the human population (7.4 billion people).

[xlvii]However, the developing world is a growing market of consumption. These nations are quickly

gaining more purchasing power and it is expected that the Global South, which includes cities in Asia, Latin America and Africa, will account for 56% of consumption growth by 2030. This means that consumption rates will plateau for the developed nations and shift more into these developing countries.

The theory of overpopulation reflects issues of carrying capacity without taking into account per capita consumption, by which developing nations are evaluated to consume more than their land can support. The United Nations estimate that world population will reach 9.8 billion in the year 2050 and 11.2 in 2100. This growth will be highly concentrated in the developing nations which also poses issues with inequality of consumption. The nations that will come into consumer dominance must abstain from abusing certain forms of consumption, especially energy consumption of CO_2. Green parties and the ecology movement often argue that consumption per person, or ecological footprint, is typically lower in poorer than in richer nations.

In understanding the effects of over-consumption, it is pertinent to understand what causes the phenomenon. There is a spectrum of goods and services that the world population constantly consume. These range from food and beverage, clothing and footwear, housing, energy, technology, transportation, education, health and personal care, financial services and other utilities. Each of these require a different resource and once that resource is exploited to a certain point that qualifies as over consumption. Since the developing nations are rising quickly into the consumer class, it is important to note the trends happening in these nations. According to the World Bank, the highest shares of consumption lie in food and beverage and clothing and footwear. This applies regardless of sector of income.

Causes of Overconsumption

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[xlviii]Two main factors of why we buy so much and so often is due to planned and perceived obsolescence. This factor of production was introduced first in the United States and it revolves around the design of products and with these methods, the products are intentionally designed to be discarded after a short amount of time. As of 2012, only 1% of goods purchased were still in use after 6 months. This is due to planned and perceived obsolescence. When it is planned, designers create products that will not be able to work after a certain amount of time but they work for

enough time to ensure the customers will come back to buy again. Perceived obsolescence comes in a lot with fashion and trends and fueled by advertising and media consumption. Through this technique, consumers are convinced that certain products do not have value anymore because it is out of style, and in order to have value, consumers must buy more up to date styles. Here is where fast fashion was born. As of 2015, the top five consumer markets in the world included the United States, Japan, Germany, China and France. The main drivers of overconsumption leading to resource scarcity globally is Energy, Food and Minerals.

Global Energy Consumption Pattern

[xlix]In 2020, world population will grow to 8 billion, the global economy will approach US$ 80 trillion, and the wireless Internet will be connecting almost half of humanity. In this article there will be discussion on source of energy and Global annual Energy Consumption pattern in respect of annual GDP (up to the Year of 2030). Energy is broadly classifies into two main groups: renewable and Non-renewable. Renewable energy is available in plenty and by far most the cleanest sources of energy available on this planet. Non-renewable sources are not environmental friendly and can have serious effect on our health. In this article it has proved that, GDP and Energy Consumption of developing countries are increasing exponentially. Whereas GDP and Energy Consumption of developed countries are increasing linearly.

First, it is necessary to differentiate between primary and final energy. Primary energy describes the energy stored in fossil energy sources like oil, coal and gas. In addition to that there is energy from uranium and biomass as well as energy from physical processes driven by solar radiation, wind and hydraulic power. In contrast, final energy is energy actually available to the final consumer. The flow from energy production to its consumption is displayed by energy balances that show the quantity, transformation and consumption of energy in a country or economic area are shown during a certain period (see AG Energiebilanzen 2010). They provide information about both the amount and structure of energy consumption, the share of imported and exported energy as well as consumption patterns and conversion losses. They also constitute the basis for determining CO2 emissions. Generally, energy balances are a prerequisite for economic and energy policy decisions and forecasts.

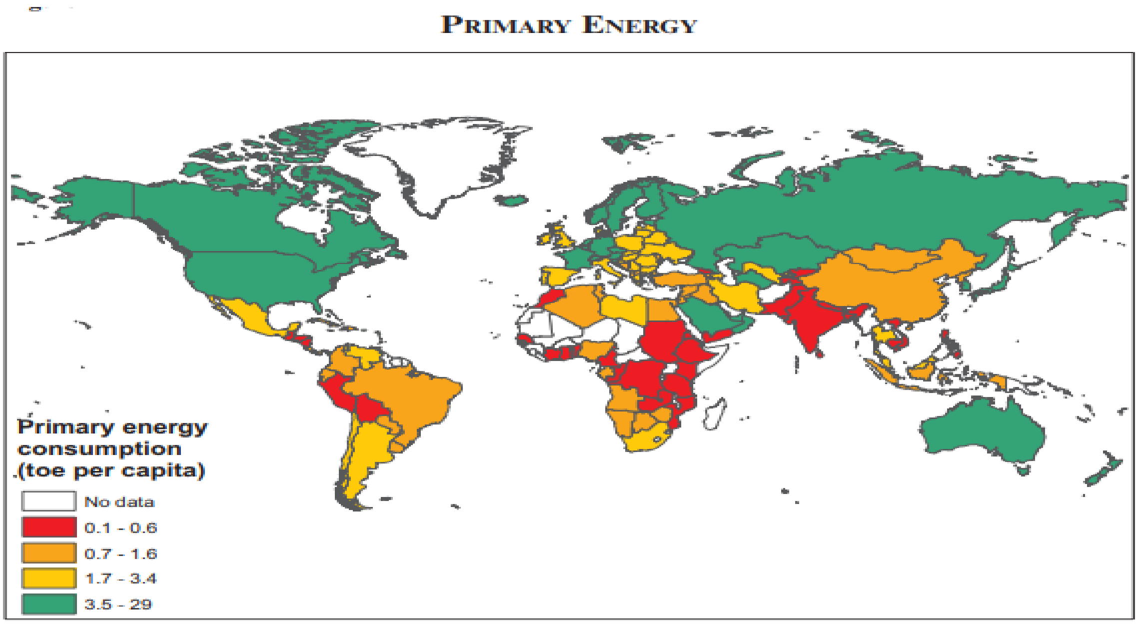


Fig. 2.2 Primary Energy Consumption at Global Level

Domestic Electricity Consumption (India)

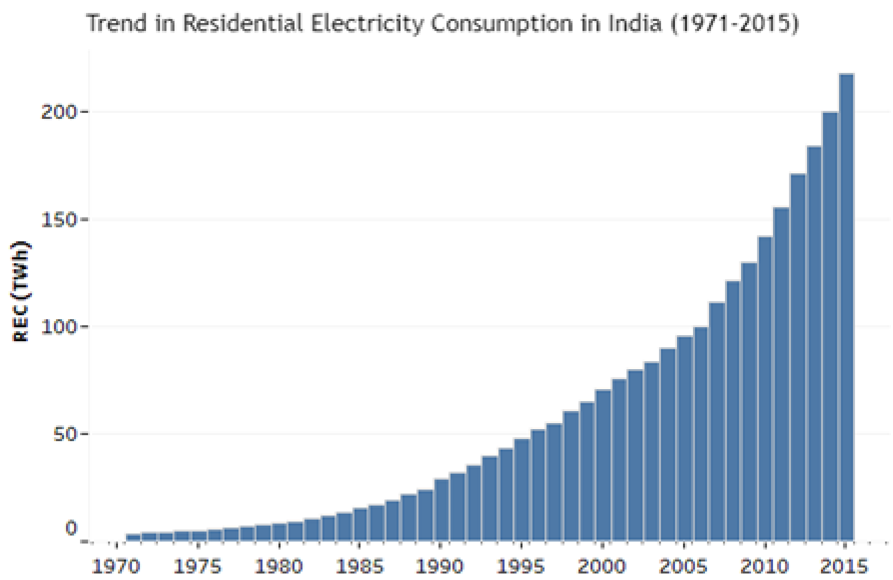


Fig 2.3 Trends in Residential Electricity Consumption in India (1971 – 2015)

Electricity consumption in Indian homes has tripled since 2000. The percentage of households with access to electricity has increased from 55% in 2001 to more than 80% in 2017. In 2014, an electrified Indian household consumed about 90 units (kWh) of electricity per month on an average; enough to run four tube-lights, four ceiling fans, a television, a small refrigerator, and small kitchen appliances with typical usage hours and efficiency levels in India. This is three-fourths of the average monthly household consumption in China, a tenth of that in the USA, and a third of the world average. In this post, we take a closer look at data on India’s residential electricity and the disparities in access and consumption across states. We also reveal some inconsistencies between different sources, pointing to the need for better data.

[i]India’s residences, which avail modern energy services such as cooling, clean cooking, lighting, and media access are predicted to account for 85% of the country’s floor space by 2050. The population’s development and lifestyle needs, coupled with the government’s aim to provide uninterrupted electricity to all homes by 2019, is projected to increase electricity consumption five to six times between 2014 and 2030. A combination of rapid electrification, increasing incomes, and technological development will result in people buying more appliances and using more electricity to run them. Already, the residential sector uses about 25% of the country’s total current electricity consumption (with a nine per cent growth in 2015-16) – at a time when less than a quarter of all households do not have an electricity connection and those that do face frequent power cuts.

All states show considerable increase in total residential electricity consumption in recent years according to data compiled by the Central Electricity Authority (CEA) from distribution companies (see Figure 1). Between 2004 and 2015, states like Assam, Bihar, Chhattisgarh, and Jharkhand with low initial household electrification showed a high growth rate of their residential electricity use (about 11%-16%). States with higher household electrification like Delhi, Punjab, Haryana, and Tamil Nadu grew at lower, but still substantial, rates (6%-8%), with high absolute numbers.

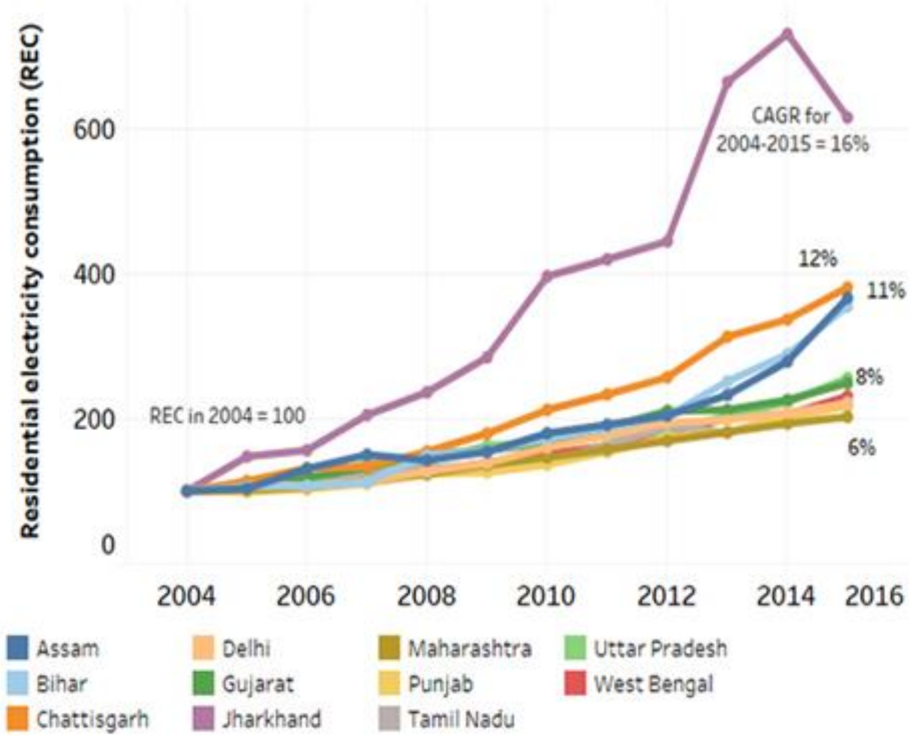


Fig 2.4 Residential Electricity Consumption growth in selected State (2004 – 2015)

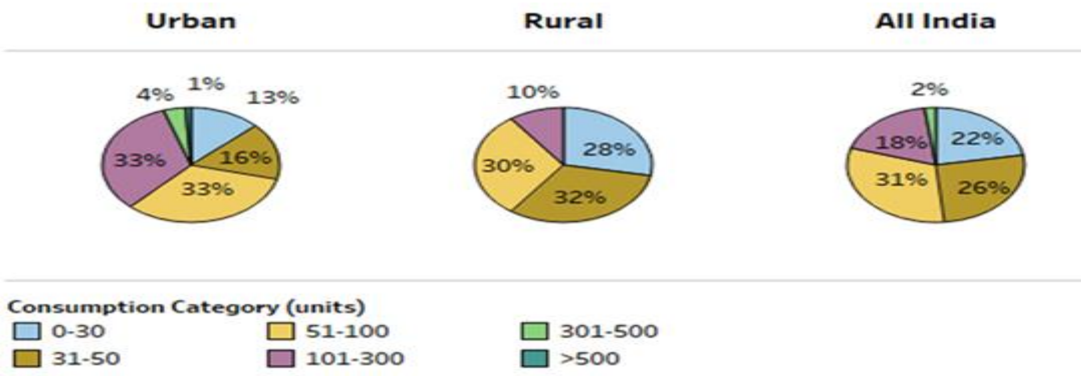
Three insights emerge

- One, an electrified household in Delhi consumes about 250-270 units or kWh of electricity per month on average, approximately the same average amount consumed by an electrified household in Germany. At the same time, such an electrified household in Delhi consumes significantly more than other Indian cities (Chandigarh: 208 units; Ahmedabad: 160 units; Puducherry: 150 units; and Mumbai: 110 units). This is in part due to high ownership of air-conditioners (12% of total households) and air-coolers (70%), and tariff subsidies in Delhi. Yet, other socio-economic reasons still need to be examined.
- Two, electrified households in larger states like Maharashtra, Gujarat, and Tamil Nadu, with higher rates of electrification, consume on an average a lower amount of about 80-90 units per month. Karnataka is on the lower end with about 60 units. On the other hand, households in Punjab (about 150 units) and Haryana (about 110 units) consume much more. While there may be some discrepancies in the data due to incorrect reporting on use and number of consumers by distribution companies, the

scale of these discrepancies is likely to be small given the limited number of un-metered and illegal connections in the residential sector.

- Three, states like Uttar Pradesh (UP), Jharkhand, and Chhattisgarh show high monthly household electricity consumption. It is unlikely that states with a high share of newly electrified households and low reliability of power supply consume as high as an average household in Chandigarh or Mumbai. The reported household consumption is high possibly due to metering issues. For instance, 40% of the total residential connections in UP are rural un-metered connections. As their actual consumption is not metered, the distribution companies estimate their consumption based on norms approved by the regulator (currently the norm is 144 kWh/kW/month, a high number). Distribution companies have not conducted any sample studies to justify this norm despite being asked by the regulators. High estimation of consumption from un-metered connections as well as measurement issues in metered connections can mask the actual consumption.

Finally, the electricity consumption within states also exhibit significant inequity at the household level. According to the National Sample Survey Office (NSSO)'s surveys, about 20% of electrified households consume less than 30 units of electricity per month, while about 80% consume less than 100 units per month. In rural areas, 90% of the electrified households consume less than 100 units. This distribution varies with states. In most states, about 15-20% of all the households consume less than 30 units per month. The states consuming the least electricity are Karnataka, West Bengal, Bihar, and Jharkhand. For more details on results see our



recent report.

Fig 2.5 Households in India according to Monthly Consumption

Industrial Energy Consumption

The industrial sector uses more delivered energy than any other end-use sector, consuming about 54% of the world's total delivered energy. The industrial sector can be categorized by three distinct industry types: energy-intensive manufacturing, non-energy-intensive manufacturing, and nonmanufacturing. The mix and intensity of fuels consumed in the industrial sector vary across regions and countries, depending on the level and mix of economic activity and on technological development. Energy is used in the industrial sector for a wide range of purposes, such as process and assembly, steam and cogeneration, process heating and cooling, and lighting, heating, and air conditioning for buildings. Industrial sector energy consumption also includes basic chemical feed stocks. Natural gas feedstockare used to produce agricultural chemicals. Natural gas liquids (NGL) and petroleum products (such as naphtha) are both used for the manufacture of organic chemicals and plastics, among other uses.

Overall, total industrial sector energy use increases from 73 quadrillion Btu in 2012 to 85 quadrillion Btu in 2040 in the OECD (Organisation for Economic Co-operation and Development) countries, and from 149 quadrillion Btu in 2012 to 225 quadrillion Btu in 2040 in the non-OECD countries. OECD industrial sector energy use grows slowly in the IEO2016 Reference case, averaging 0.5%/year from 2012 to 2040. The industrial sector accounts for approximately 40% of total OECD delivered energy use from 2012 to 2040. In the non-OECD industrial sector, the share of delivered energy use declines from 64% in 2012 to 59% in 2040, as many emerging non-OECD economies move away from energy-intensive manufacturing, while energy use grows more rapidly in all other end-use sectors.

The following industries are considered to be energy-intensive food, pulp and paper, basic chemicals, refining, iron and steel, nonferrous metals (primarily aluminum), and nonmetallic minerals (primarily cement). Together, they account for about half of all industrial sector delivered energy use. In 2012, OECD energy-intensive industries accounted for about 54% of the region's total industrial sector energy consumption, and non-OECD energy-intensive industries accounted for about 51% of the industrial sector total. Consequently, the quantity and fuel mix of future industrial sector delivered energy consumption will be determined largely by the overall levels of energyconsumption in those seven industries. In addition, the same industries emit large quantities of carbon dioxide (CO_2), related to both their energy consumption (combustion emissions) and theirproduction processes (process emissions). Energy consumption shares of the energy-intensiveindustries compared with all industrial sector energy consumption (including feedstockconsumption) in 2012 and 2040 for the OECD and non-OECD, respectively.

The energy consumptionshares of the energy-intensive industries are shown as percentages of total delivered energy consumption in the OECD and non-OECD industrial sectors. Increases in energy efficiency and changes in industrial gross output affect the growth of industrial sector energy consumption. Anticipated energy efficiency improvements in the industrial sector temper the growth of industrial energy demand, particularly for the energy-intensive industries. Recycling is a key contributor to industrial energy efficiency improvements, especially in the pulp and paper, iron and steel, and nonferrous metals industries (see box on page 120). Among the energy-intensive industries, the largest consumer of delivered energy is the basic chemicals industry, which in 2012 accounted for about 19% of total delivered energy consumption in the OECD industrial sector and about 14% in the non-OECD industrial sector. In both regions, the basic chemicals share of industrial energy use in the IEO2016 Reference case rises to about 20% in 2040 (Figure 7-4 and Figure 7-5). The chemicals industry in general uses petrochemical feedstocks, which are included in its energy use. In 2012, petrochemical feedstocks accounted for roughly 60% of the energy consumed in the chemicals sector (which includes both energy-intensive basic chemicals and nonenergy-intensive other chemicals). Intermediate petrochemical products (or building blocks), which go into products such as plastics, require a fixed amount of hydrocarbon feedstock as input. For any given amount of chemical output, depending on the fundamental chemical process of production, a fixed amount of feedstock is required, which greatly reduces opportunities for decreasing fuel consumption in the absence of any major shifts toward recycling and bio-based chemicals.

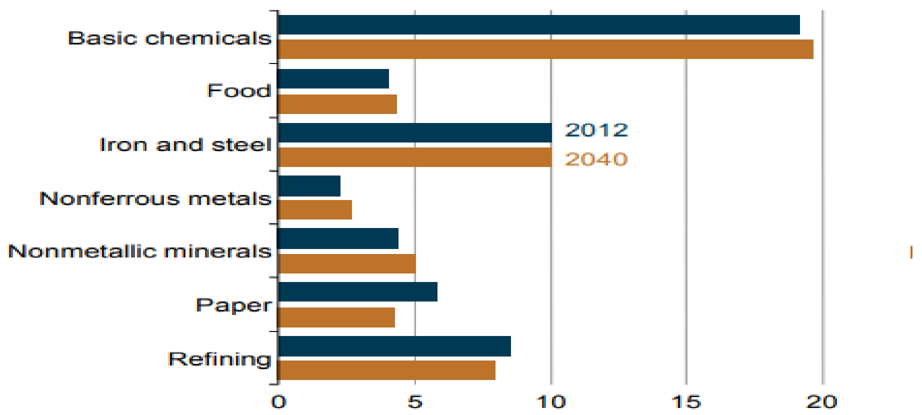


Fig 2.6 Energy-intensive industry shares of total OECD industrial sector energy consumption, 2012 and 2040 (percent of total)

Global Food Consumption Pattern

Throughout the world, major shifts in dietary patterns are occurring, even in the consumption of basic staples towards more diversified diets. Accompanying these changes in food consumption at a global and regional level have been considerable health consequences. Populations in those countries undergoing rapid transition are experiencing nutritional transition. The diverse nature of this transition may be the result of differences in socio-demographic factors and other consumer characteristics. Among other factors including urbanization and food industry marketing, the policies of trade liberalization over the past two decades have implications for health by virtue of being a factor in facilitating the 'nutrition transition' that is associated with rising rates of obesity and chronic diseases such as cardiovascular disease and cancer.

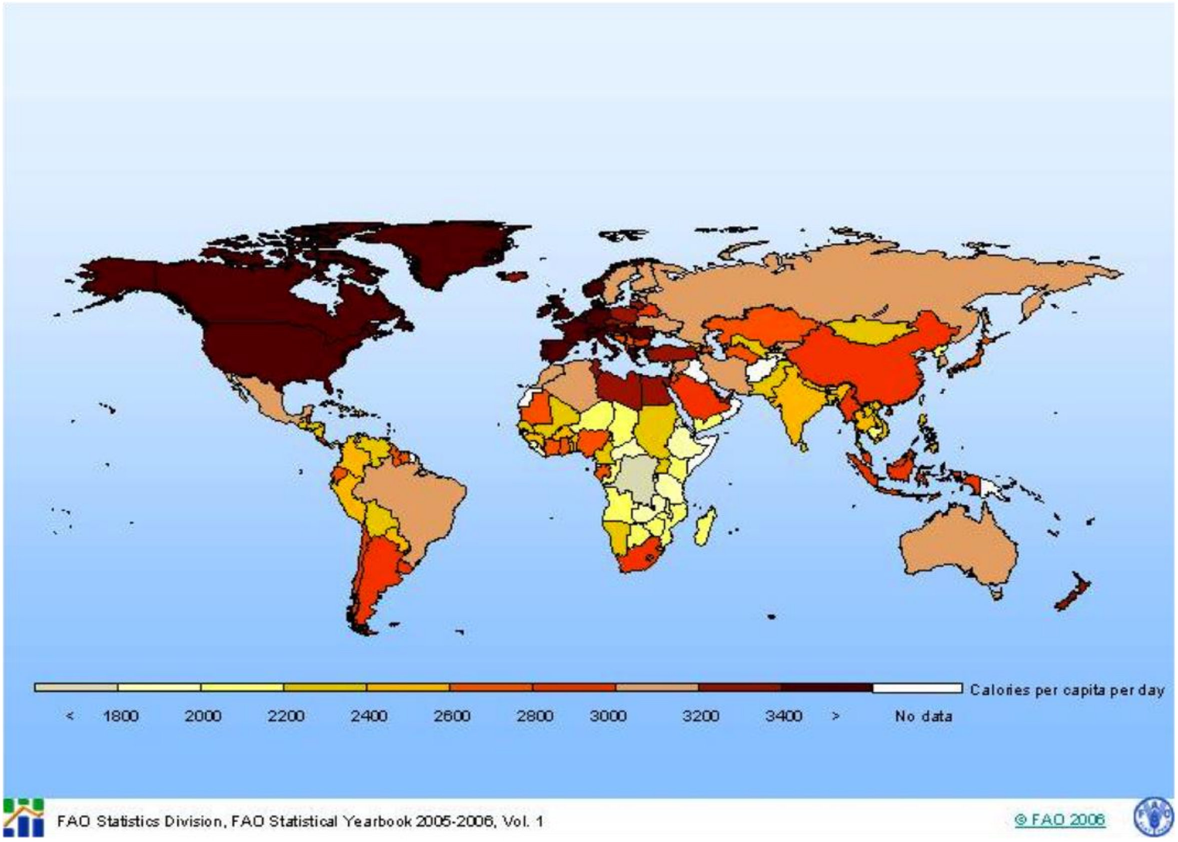


Fig 2.7 Global Food Consumptions Trends

Changes in agricultural practice over the past 50 years have increased the world's capacity to provide food for its people through increases in productivity, greater diversity of foods and less seasonal dependence. Food availability has also increased as a consequence of rising income levels and falling food prices. This has resulted in considerable changes in food consumption over the past 50 years.

[li]Economic development is normally accompanied by improvements in a country's food supply and the gradual elimination of dietary deficiencies, thus improving the overall nutritional status of the country's population. Furthermore, it also brings about qualitative changes in the production, processing, distribution and marketing of food. Increasing urbanization will also have consequences for the dietary patterns and lifestyles of individuals, not all of which are positive. Changes in diets, patterns of work and leisure - often referred to as the "nutrition transition" - are already contributing to the causal factors underlying non-communicable diseases even in the poorest countries. Moreover, the pace of these changes seems to be accelerating, especially in the low-income and middle-income countries.

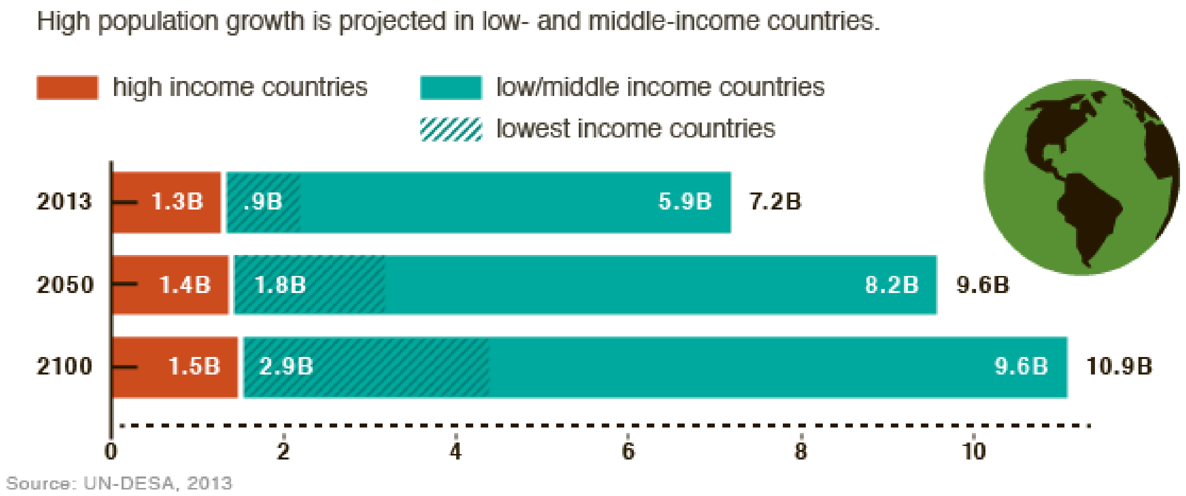


Fig 2.8 High Population growth is projected in low and middle-income countries

[lii]The dietary changes that characterize the "nutrition transition" include both quantitative and qualitative changes in the diet. The adverse dietary changes include shifts in the structure of the diet towards a higher energy density diet with a greater role for fat and added sugars in foods, greater saturated fat intake (mostly from animal sources), reduced intakes of complex carbohydrates and dietary fibre, and reduced fruit and vegetable intakes. These dietary changes are compounded by lifestyle changes that reflect reduced physical activity at work and during leisure time. At the same time, however, poor countries continue to face food shortages and nutrient inadequacies.

In short, it would appear that the world has made significant progress in raising food consumption per person. The increase in the world average consumption would have been higher but for the declines in the transition economies that occurred in the 1990s. It is generally agreed, however, that those declines are likely to revert in the near future. The growth in food consumption has been accompanied by significant structural changes and a shift in diet away from staples such as roots and tubers towards more livestock products and vegetable oils. Table below shows that current energy intakes range from 2681 kcal per capita per day in developing countries, to 2906 kcal per capita per day in transition countries and 3380 kcal per capita per day in industrialized countries. Data shown in below Table suggest that per capita energy supply has declined from both animal and vegetable sources in the countries in economic transition, while it has increased in the developing and industrialized countries.

The production of consumer goods is supported by a variety of inputs which ensure that the good will align with consumer preference in seeking utility maximisation. Therefore the value of the good can be somewhat justified by the input levels supporting production. Such 'high value' goods are preferred to those with fewer inputs, on account of better achieving utility maximisation, reflected through a higher willingness to pay. A similar analogy is drawn when food is considered to be the consumptive item of choice. Food items that require a greater amount of resource input are typically more expensive on account of the higher opportunity cost of production to those with fewer resource requirements. On account of seeking utility maximisation, only households with relatively high disposable incomes are able to consume higher value food items. The premise that higher resource intensive items will experience greater demand by richer households. Arguably, these goods contain a greater capacity to satisfy utility, consistent with evolving tastes and preferences of households influenced by economic development.

Table 2.1 Vegetable and animal sources of energy in the diet (kcal per capita per day)

Region	1967 - 1969			1977 - 1979			1987 - 1989			1997 - 1999		
	T	V	A	T	V	A	T	V	A	T	V	A
Developing countries	2059	1898	161	2254	2070	184	2490	2248	242	2681	2344	337
Transition countries	3287	2507	780	3400	2507	893	3396	2455	941	2906	2235	671
Industrialized countries	3003	2132	871	3112	2206	906	3283	2333	950	3380	2437	943

T, total kcal; V, kcal of vegetable origin; A, kcal of animal origin (including fish products).

Source: FAOSTAT, 2003.

Analyzing food demand patterns with respect to resource intensity requires the 13 food items be categorised with respect to resource input requirements in production. Three major agricultural resource inputs - fossil fuels, land and water – underpin the organisation of the resources into their respective categories. The below Table displays the food items corresponding to categories of low, moderate and high resource production requirements.

Low	Moderate	High
Rice	Noodles, Rice Noodles, other chips	Beef, buffalo, goat
Cassava/Tapioca	Tofu/Tempe	Chicken, duck
Sago/Flour	Granulated Sugar	Fish, Oyster, Shrimp, Squid
Other Staples (potatoes, yams)	Milk (fresh, canned, condensed)	Cooking Oil
Green Vegetables	Salt	Bottled Water
Fruits	Salted Fish	

Fig 2. 9 Resource Input Categories

Changes in Food Consumption Pattern in India

Food consumption pattern have changed over time being influenced by income, individual preferences, as well as geographical and social factors. liiiThe shift in food consumption pattern was much faster in developing countries than the developed countries. In India, there was a dramatic change in food consumption pattern in the post-Green Revolution period. The changes in food consumption pattern have been identified in both rural & urban areas, and people from different socio-economic strata. Besides, there is a clear difference of food preference between urban and rural areas and also for rich and poor. The average calorie intake has declined in India even though the real monthly expenditure has increased.

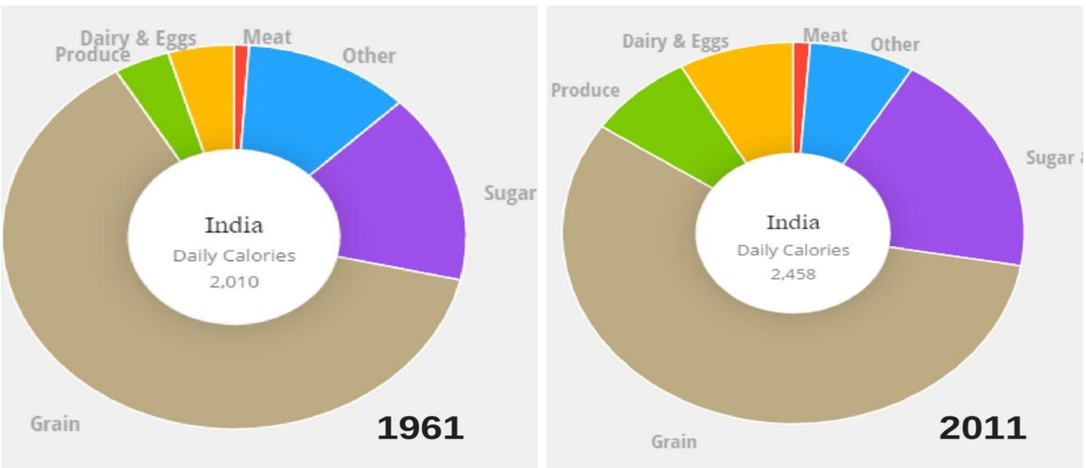


Fig 2.10 India - Changing Food Consumption

The per capita cereal consumption declined since the early seventies despite a significant increase in per capita cereal production. At the same time, a huge part of population in India continued to be food insecure. Then the question is, whether people voluntarily reduced calorie intake despite poor nutritional indicators and prevalent food insecurity, or some external factors forced them to change the food consumption pattern Increase in per capita income, change in life-style & occupation and increase in levels of urbanization are the most prominent factors contributing to the changes in food consumption pattern. India, with its huge population, and current economic conditions is in a unique position to experience the effects of nutrition transition like many other developed and developing countries. In this context, it is important to examine how the food demand will change in future, and how the country will meet the requirements.

Global Mineral Consumption Pattern

For many developing countries, economic growth has just begun; however, China's economic growth is not new. Since the late 1980s, economic growth in China has been between 7 and 9 percent annually, doubling the economy every 8 to 10 years. Developing has been undergoing industrialization, moving through a series of stages that include development of infrastructure, followed by development of light manufacture, development of heavy manufacture, increased consumption of consumer goods, and finally, by the development of a service economy. Based upon the experiences of the Federal Republic of Germany and Japan during the post-World War II period, and of the Republic of Korea in the period 1970-95, changes begin at roughly 5-year intervals and each of the stages takes about 20 years to complete- with stages overlapping. During each stage of economic development, consumption of particular mineral commodities rises dramatically.

For example, the first or infrastructure stage is characterized by large increases in consumption of cement, crushed stone, and sand and gravel; cement consumption may rise from a few tens of kilograms per person per year to 0.5 to 1 ton of cement per person per year. During the second or light manufacturing stage, consumption of copper may increase from less than a kilogram per person per year to around 10 kilograms per person per year. In the third or heavy manufacturing stage, consumption of aluminum, iron ore, and steel rises. For example, aluminum consumption typically increases from less than a kilogram per person per year to 10 to 30 kilograms per person per year. The consumer goods stage of development is characterized by increased consumption of durable goods such as automobiles. Increases in the consumption of metals with specialty applications such as nickel, which is used in stainless steel, industrial minerals, and fuels are characteristic of the fourth or consumer goods stage. Finally, high but static rates of per capita consumption of minerals in finished goods are characteristic of the ultimate services stage.

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[liv]Analysis of mineral consumption patterns shows that continued strong economic growth in developing countries with large populations has some important implications.

1. Developing countries like the BRICS (Brazil, Russia, India, China and South Africa) nations are likely to follow general patterns of development. Developing and developed nations now well along in its light manufacturing stage and has begun to develop its heavy industry and even to consume durable goods such as automobiles. If Chinese consumers follow the example of their Japanese, Korean, Malaysian, and Taiwanese neighbors, Chinese auto ownership could rise from about 10 to 100 autos per thousand people within the next 7 to 10 years. Unless there is a significant improvement in automobile engines, this could create a significant increase in environmental residuals.

2. Increased environmental residuals from developing countries will become a major issue both domestically in the developing countries and internationally. Transnational flows of environmental residuals could increase disputes between nations.
3. Increased competition could take place among countries seeking sources of mineral commodities to supply industrial production. National policies regarding domestic and international resource ownership and policies concerning mineral exports are examples of ways that governments could attempt to secure advantages for domestic industries.
4. As the developing countries increase their per capita income, several changes are likely. Higher national incomes are likely to lead to increased consumption of mineral commodities. At the same time, higher national incomes are likely to increase resistance to mineral production because preferences for environmental goods and services increase with income. This could create difficulties for companies seeking to increase exploration for new mineral deposits and to extend lives for some deposits that were thought to be reaching the end of their production.
5. Increased volatility in mineral prices could result from slowdowns in developing economies, which are producing and consuming very large quantities of mineral commodities. If during such a downturn, developing countries turn their growing capacity to produce mineral commodities to exports to developed countries, significant trade disputes could take place. The rapid increase in imports of cement from Asia into the United States following the downturn of Asian economies in 1997 is a small example of what could happen.
6. In developed countries, high prices and increased competition for mineral commodities could bring additional economic pressure on manufacturers. New strategies could be developed that would use information technologies together with innovations in product design to reduce the costs of disassembling durable goods at the end of life of products and of sorting materials. This could increase reuse, remanufacture, and recycling of components and help manufacturers to avoid high cost new materials.
7. Rapid changes in mineral consumption are creating conditions where reliable information for economic and national security planning and developing public policies will be increasingly important.

Continued growth of the economies of China and other large developing countries could result in a period of rising real prices for mineral commodities. This would be in contrast to the last 30 years, during which real prices of many minerals have declined. Over the next 20 years, mineral commodity price trends may more closely resemble the period from 1950 to 1970 than the last 30 years because of the proportion of the world's economies undergoing development.

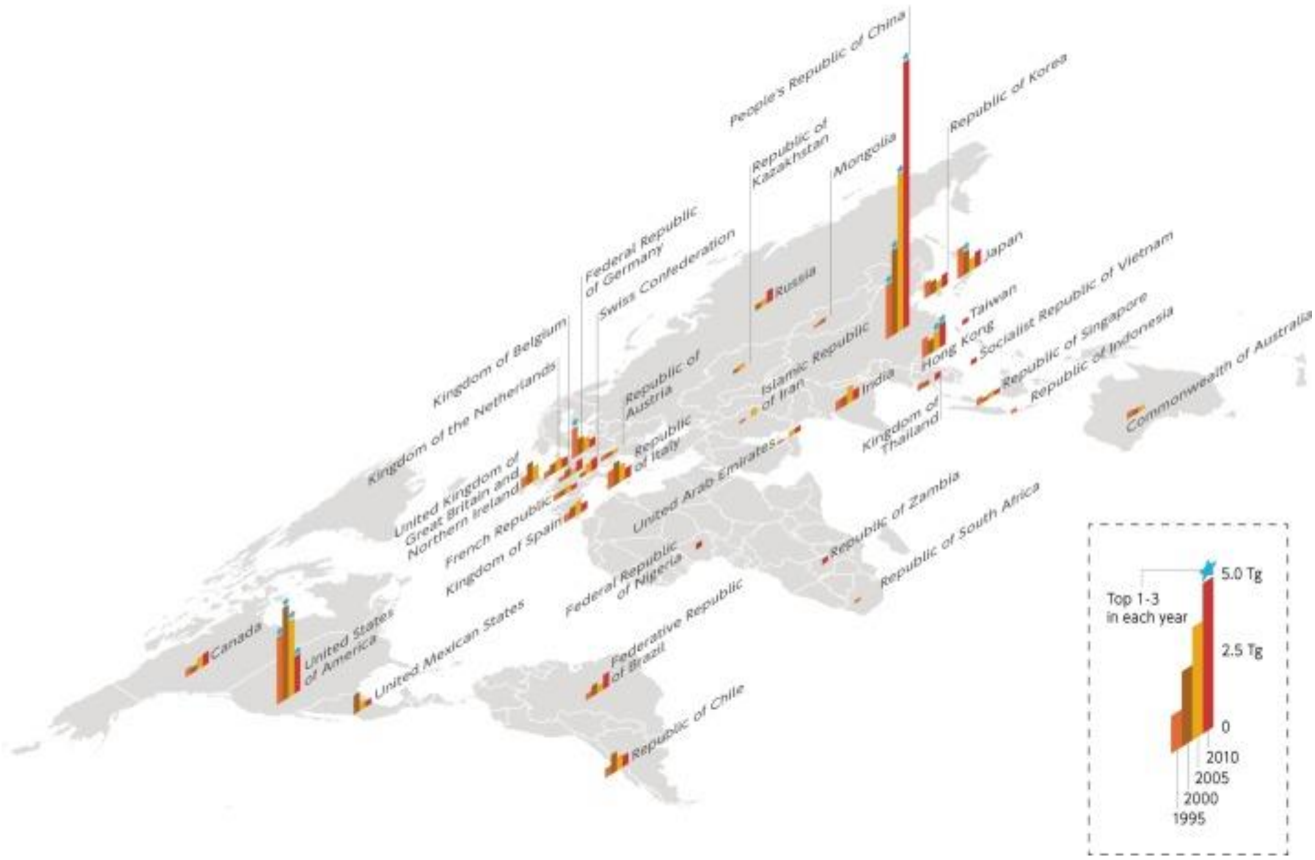


Fig 2.11 Distribution of the 25 countries and regions with the largest apparent consumption of copper in 1995, 2000, 2005, and 2010.

The rapid economic growth in developed and developing countries is greatly increasing global mineral consumption, changing global patterns of mineral production, trade, and increasing releases to the environment.

2.4 Sustainable Consumption and Production

The last few decades have been a time of dynamic changes across the world, with millions of people lifted out of poverty and a number of countries reaching middle income status. However, these achievements and changes have come at a significant cost to the environment. Increasing demand for energy, food, water and other resources has resulted in resource depletion, pollution, environmental degradation and climate change, pushing the earth towards its environmental limits. With humans now consuming more resources than ever before, the current patterns of development across the world are not sustainable.

One of the key elements for achieving sustainable development is the transition towards Sustainable Consumption and Production (SCP). This need was first highlighted at the Rio Earth Summit in 1992 and was recently reiterated in the outcomes of the Rio +20 summit, with the adoption of the 10 Year Framework Programmes. SCP is about fulfilling the needs of all while using fewer resources, including energy and water, and producing less waste and pollution. It can contribute to poverty alleviation and the transition towards a low carbon, green economy and is essential for improving the lives of the world's poorest people, who depend so closely on the natural resources provided by their environment. SCP can lead to an improved quality of life and greater employment opportunities, complementing poverty reduction strategies. In particular the continuing infrastructure developments required across the region provide immense opportunities for SCP. As SCP cuts across all different sectors, it requires a holistic approach and the engagement of numerous stakeholders. Collaboration between multiples areas and levels within government is necessary to develop, implement, monitor and evaluate successful SCP policies. It requires policy to not just improve production, but also to support consumers to move towards sustainable consumption choices. Therefore everyone in society has a role to play in this transition including governments, educators, the private sector and each and every consumer.

Definition of Sustainable Consumption & Production (SCP)

The concept of SCP has evolved over time and is defined in a number of ways. A commonly used definition is "the use of services and related products which respond to basic needs and bring a better quality of life while minimising the use of natural resources and toxic materials as well as the emission of waste and pollutants over the life cycle of the service or product so as not to jeopardise the needs of future generations" (ISSD 1994).

Another widely used and more recent definition is provided by UNEP "SCP is a holistic approach to minimising the negative environmental impacts from consumption and production systems while promoting quality of life for all" (UNEP 2011). The International Institute for Sustainable Development list 3 other definitions of sustainable consumption and/or production and doubtless there will be even more by other bodies. Regardless of definitions, the underlying principles of SCP must be clear.

Fig 2.12. Sustainable Consumption and Production

Key principles of SCP

1. Improving the quality of life without increasing environmental degradation and without compromising the resource needs of future generations.
2. Decoupling economic growth from environmental degradation by
    - Reducing material/energy intensity of current economic activities and reducing emissions and waste from extraction, production, consumption and disposal.
    - Promoting a shift of consumption patterns towards groups of goods and services with lower energy and material intensity without compromising quality of life.
3. Applying life-cycle thinking which considers the impacts from all life-cycle stages of the production and consumption process.
4. Guarding against the re-bound effect, where efficiency gains are cancelled out by resulting increases in consumption (UNEP 2011).

Sustainable Production

[lv]Sustainable Production is the creation of goods and services using processes and systems that are

- Non-polluting
- Conserving of energy and natural resources
- Economically viable

- Safe and healthful for workers, communities, and consumers
- Socially and creatively rewarding for all working people

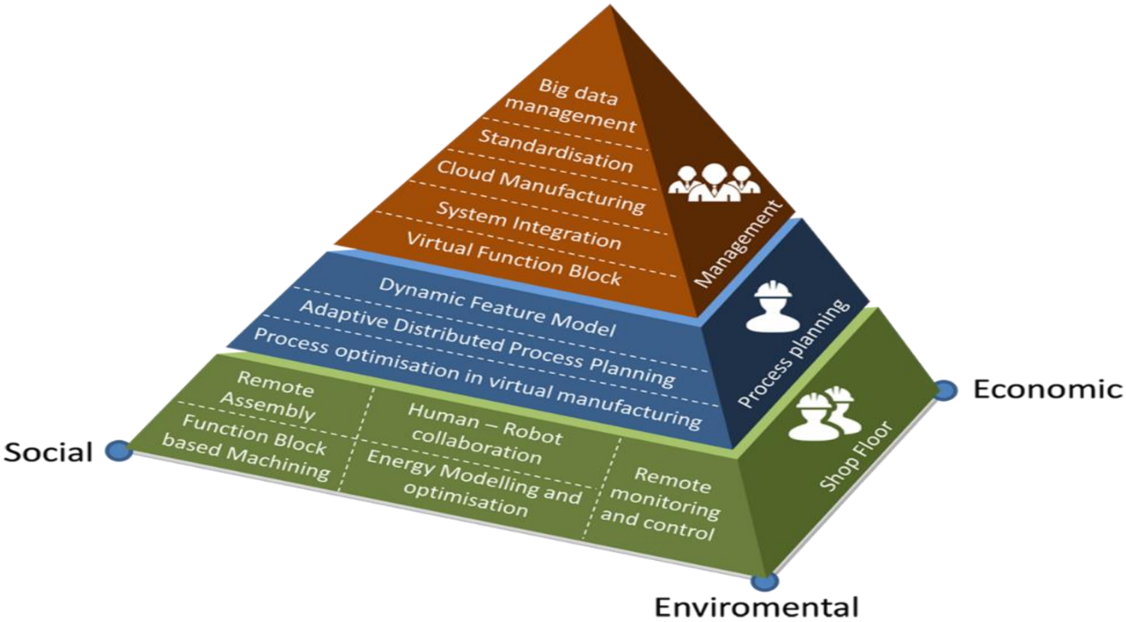


Fig 2.13 Sustainable Production System

If production is sustainable, then the environment, employees, communities, and organizations—all benefit. These conditions can lead, always in the long term, and often in the short term, to more economically viable and productive enterprises.

The conceptual spark of sustainable production lies in valuing longer-term consequences and benefits over short-term profits. Organizations can thrive by investing in well-designed safer products, resource efficient technologies and processes, and trained and empowered employees.While health and safety (H&S), workers' rights etc. define the social and institutional, and profitability theEconomic dimension, provision and production efficiency are at the heart of the environmental dimension of sustainable production. However, enforcing specific environmental standards, substance legislation and the forthcoming framework are not superfluous efforts, but are complementary to any input reduction scheme and need to be implemented as a matter of urgency, and why substituting at least substances with proven harmless characteristics for the suspicious ones in product design would be a significant step forward. However, as long as we do not manage to design our products so as to minimise the consumption of resources from the very beginning, only limited progress towards environmentally benign production and consumption will be possible.

Although environmentally relevant only when they are disseminated, the resources accumulated in the stocks of society deserve a closer look, too. Stocks are public goods like roads or buildings, private goods like refrigerators, cars and houses, or industrial goods like machinery, railway lines and telecommunication infrastructure; they contain a vast amount of embodied material, energy and land. Goods and services can be distinguished according to their lifetime expectancy (short or long) and according to the type of market in which they are sold (fluctuating markets where products are only fashionable for a short time, or saturated markets where products are replacements).

Unlike the impression given in much of the consumption debate, not only short-lived goods are a reason for concern, but the accumulation of durables is problematic as well. On the one hand, the mere maintenance of long-lived goods and infrastructures requires an increasing volume of monetary expenditures as well as environmental space use, without providing additional welfare they need to be cleaned, upgraded, repaired or renovated to continue providing the same service. This creates a positive feedback cycle as a rule of thumb, the more materials we have fixed in the stocks, the more flows we need to maintain them. On the other hand, the stocks are bound to become waste as everything else, although after a longer time span. In the meantime, they are a restriction to behavioural options other than those foreseen at the time of their construction.

Different aspects of human development – literacy, life expectancy, and per capita income – have different costs in terms of environmental pressure. High achievements in literacy and life expectancy are possible based on moderate levels of natural resource use. High per capita income, by contrast, almost always requires high levels of natural resource use and emissions.

A study by Steinberger and Roberts (2010) found that by the mid 1970's, the global supply of natural resources was not sufficient to service high human development for every citizen. The same research found, analysing data for 2005, that if natural resources were equally distributed the energy and carbon levels in this year would have been more than sufficient to satisfy global human needs at high levels of human development. The authors also found that the global energy consumption and carbon emissions required to satisfy human needs will decrease with time, despite growth in population, due to overall efficiency gains in many systems of provision including housing, mobility, food, energy and water, in delivering a high material standard of living.

This does not mean, however, that the overall level of natural resource demand and the related level of emissions will start to reduce any time soon. This is dependent on achieving large investments in green technologies, buildings and infrastructure that need less materials and energy and produce less emissions and waste.

Sustainable Consumption

[lvi]As a compliment to analyses of production and its processes, Sustainable Consumption (SC) is the study of resource and energy use (domestic or otherwise). As the term sustainability would imply,

those who study SC seek to apply the concept of "continuance"—the capacity to meet both present and future human generational needs. SC, then, would also include analyses of efficiency, infrastructure, and waste, as well as access to basic services, green and decent jobs and a better quality of life for all. It shares a number of common features with and is closely linked to the terms sustainable production and sustainable development. Sustainable consumption as part of sustainable development is a prerequisite in the worldwide struggle against sustainability challenges such as climate change, resource depletion, famines or environmental pollution.

[lvii]Sustainable consumption has two important aspects, the need to attend to under-consumption and on the other hand, the rising consumer classes in OECD and developing countries and their very high consumption levels. Lifestyles and consumption patterns of millions of consumers in developing countries are now converging with those of OECD countries. This is particularly the case among younger and well educated elites. This global consumer class already totalled 1.7 billion people in 2004 (Worldwatch Institute, 2004) of whom almost 40% (or 680 million) lived in Asia.

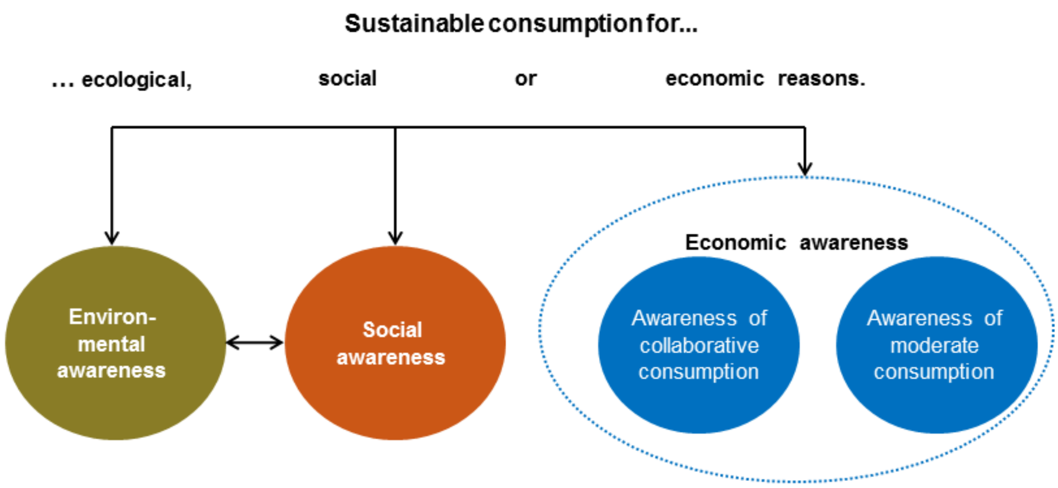


Fig 2.14 Sustainable Consumption System

Following in the footsteps of already developed countries, the consumption patterns of the new consumer classes will result in larger houses and apartments fitted with new appliances, new modes of transport and increasing private car ownership, increased air travel, new diets based on much larger amounts of meat and dairy and a whole range of new manufactured goods. There is an important opportunity to guide the transition in consumption in OECD and developing countries toward sustainability through policy settings and frameworks that privilege environmentally friendly and socially just products and services. This can happen through labelling, subsidies and information campaigns, which are all areas in which government intervention will be of great importance. Sustainable Lifestyles provides more information on such options. Governments are able to showcase best practice in their own consumption behaviour through sustainable public procurement, investment in energy efficient and low material intensity public buildings such as government offices, schools and hospitals, and through investing in sustainable public infrastructure. These investments will greatly pay off in terms of sustainable natural resource use and climate change mitigation while promoting sustainable choices to the greater community.

It is important to note that most of the buildings and infrastructure that will be operated by 2050 do not exist today, which offers a large window of opportunity for investing today in the sustainable infrastructure that will have a lasting legacy towards the middle of the century. This is especially true for fast growing cities in developing countries across Asia, LAC and Africa. There is also great potential for urban infrastructure improvements in car based cities in North America, Canada and Australia and elsewhere in the world.

The 20thcentury, and especially the second half of the century, was a time of remarkable change and progress for humankind. The world has seen global increases in population, average incomes (and consumption rates), urbanisation (and infrastructure investment) and huge growth in production activities. In many countries these trends have contributed immensely to economic development, creating jobs, increasing the material standard of living of many people, enabling investment in public infrastructure and reducing poverty levels. Many countries have modernised their societies and economies enabling the greatest level of material wellbeing ever experienced. These changes were most prevalent in OECD countries and in urban centres in developing countries.

The rapid economic growth and human development that has occurred since the 1950s has come at a cost, however, of very large and growing environmental pressures and impacts. The use of natural resources –biomass, fossil fuels, ores, minerals and water – has grown dramatically from less than 10 billion tonnes in 1950 to over 70 billion tonnes in 2010 (UNEP, 2011). This level of resource use was largely based on the assumption of limitless resources and overlooked the connections between resource use and environmental impacts.

The rise in resource use has been coupled with growth in waste and emissions contributing to a series ofpressure points including climate change, reduced food security, water scarcity and air pollution. It has also lead to supply insecurity for a number of resources that are strategically important in modern production and consumption systems (Weisz and Schandl, 2008). In addition, since the 1980s there has been a growing gap between wealthy and poor people in both developing countries and across the OECD. More recently, the governance and functioning of the global economic systems has been challenged during the global financial crisis that started in 2008.

A modern lifestyle based on current patterns of consumption and production requires a large amount of natural resources, of between 25 and 30 tonnes of materials per capita, per annum (Wiedmann et al., 2013). Multiplied by the 9 billion people expected by 2050 this would mean a global material use of between 225 and 270 billion tonnes or three to four times the amounts of 2010. The investments needed to establish global extractive capacity adequate for such high levels of resource use would be huge and potentially unaffordable. Such quantities of resources are simply not available, and the absorptive capacity of the earth's ecosystems are already stretched at much lower global levels of resource use. It is therefore evident that current patterns of consumption and production are environmentally unsustainable and socially inequitable.

To accommodate 9 billion people and allow for high human development for the majority a fundamental restructuring of current systems of production, provision and consumption is required. Economic growth, human development and wellbeing would need to be substantially decoupled from resource use and environmental impact (UNEP, 2011). Achieving gains in decoupling will not happen spontaneously, but will require well designed public policies that enable economic restructuring toward sustainable consumption and production and resource efficiency.

Current economic and business incentives are still tailored to the experience of the 20th century; a time of low resource prices that justified investing in labour productivity at the cost of resource productivity. The 21st century, however, presents a very different economic context of rising and more volatile resource prices, requiring a rethinking of political steering and business practices. Economic competitiveness and prosperity in the future will be underpinned by large investments into infrastructure and skills that enable a green and low carbon economy that services equitable opportunities for nations and people.

2.5 Eco-Labelling

An ecolabel is a label which identifies overall environmental preference of a product (i.e. good or service) within a product category based on life cycle considerations. In contrast to a self-styled environmental symbol or claim statement developed by a manufacturer or service provider, an ecolabel is awarded by an impartial third party to products that meet established environmental leadership criteria.

Ecolabelling is only one type of environmental [performance] labelling, and refers specifically to the provision of information to consumers about the relative environmental quality of a product. There are many different environmental performance labels and declarations being used or contemplated around the world.

As has been identified by the International Organization for Standardization (ISO), the overall goal of these labels and declarations is

"...through communication of verifiable and accurate information, that is not misleading, on environmental aspects of products and services, to encourage the demand for and supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement".

Type I# -- a voluntary, multiple-criteria based, third party program that awards a license which authorises the use of environmental labels on products indicating overall environmental preferability of a product within a product category based on life cycle considerations

Type II# -- informative environmental self-declaration claims

Type III# -- voluntary programs that provide quantified environmental data of a product, under pre-set categories of parameters set by a qualified third party and based on life cycle assessment, and verified by that or another qualified third party

As of July 2004, International ISO standards have been developed and implemented for Type I and Type II labelling, while work continues on development of a standard relating to Type III. Consequently, the ISO definition for Type III should be considered a "draft working definition" that could be revised.

Fig 2.15 Three Types of Environmental Performance Labelling* -- ISO Definitions

[lviii]The ISO has undertaken efforts to attempt to standardise the principles, practices and key characteristics relating to three major voluntary environmental labelling types -- Type I -

environmental labelling (i.e. ecolabels), Type II - self-declaration claims and Type III - environmental declarations (e.g. report cards/information labels). Box 1 provides general definitions of these different types. Unlike Type III environmental declarations, ecolabels reflect a determination and recognition of a products' environmental performance leadership characteristics rather than simply a presentation of quantified environmental data. In this respect, the ecolabels "flag" leadership products in the marketplace rather than requiring consumers to undertake their own comparative analyses. Box 2 highlights some further contrasting aspects of the three types of labels and declarations.

Origins of Ecolabelling

Green Stickers on consumer goods have been evolving since the 1970s. The main drivers have been energy and fuel consumption. These stickers first started appearing on major appliances after government agencies in the United States and Canada legislated their requirement. Manufacturers are also required to meet minimum standards of energy use. The automobile industry in North America is required to meet a minimum emissions standard. This led to fuel efficiency labels being placed on new automobiles sold. The major appliance manufacturers were required to use standard testing practices and place clear labels on products. The International Organization for Standardization has developed standards for addressing environmental labelling with the ISO 14000 family which grew out of ISO's commitment to support the objective of sustainable development discussed at the United Nations Conference on Environment and Development, in Rio de Janeiro, in 1992.

[lix]The origins of eco-labelling can be found in the growing global concern for environmental protection on the part of governments, businesses and the general public. Initially, and mostly in developed countries, as commercial enterprises recognised that environmental concerns could be translated into a market advantage for certain products, a number of environmental declarations and claims emerged on and in association with certain products. These included labels with such claims as "recyclable", "eco-friendly", "low energy", and "recycled content".

Such labelling of the products attracted consumers who were looking for ways to reduce adverse environmental impacts through their purchasing choices. However, these labels also threatened to confuse consumers. Without guiding standards and investigation by an independent third party, consumers could not be certain that the companies' assertions guaranteed that each labelled product was an environmentally preferable alternative.

This concern with credibility and impartiality led to the formation of private and public organisations providing third-party labelling. In many instances, such labelling took, and continues to take the form of ecolabels awarded by programs operated at national and regional (i.e. multinational) levels.

Around the world, there are many other third-party labelling systems in place, or being developed, which are "hybrids" of eco-labelling because they have narrower focuses than a normal eco-labelling program.

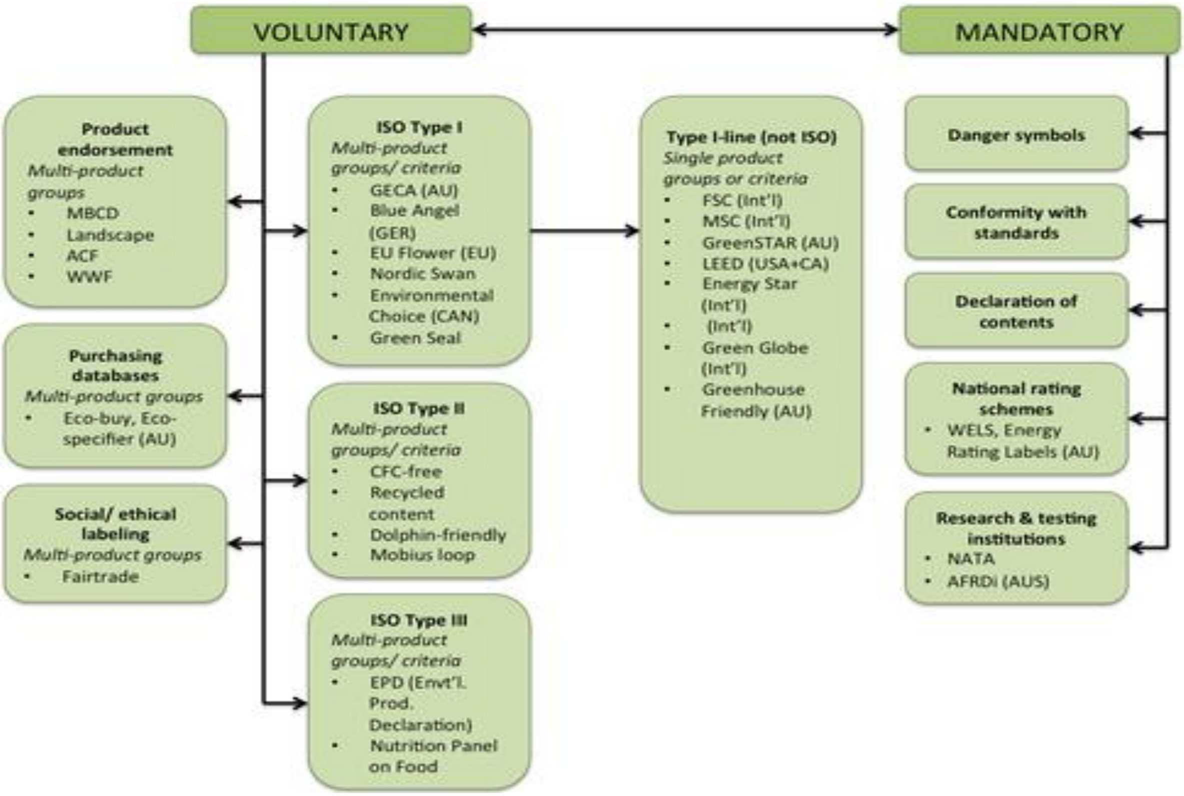


Fig 2.16 Classification of Ecolabelling

These alternative programs focus on a single sector (e.g. the forestry industry, the chemical industry, etc.), and/or address only one environmental issue (e.g. air quality, energy conservation, etc.), and/or consider only a single life cycle phase in their applications (e.g. product use, product disposal/recycling, etc.). Of further note, some other "Type I" programs have been designed and implemented to address and recognise more than simply environmental performance aspects.

In a typical eco-labelling program, product categories and eco-labelling criteria are determined by an independent organisation with assistance from a complementary technical advisory group. Generally, once a category is chosen, some form of life cycle review is conducted. This review may include raw material extraction, manufacture, distribution, use and disposal. The differentiating parameters (e.g. energy use, toxicity, etc.) are then used as the basis for criteria development.

Companies which want to participate in an eco-labelling program make application and submit their products for third party compliance testing and/or verification. If approved, the companies pay licensing fees for permission to use the program's distinctive ecolabel symbol for a specified period. Use of the ecolabel is restricted to the approved product(s), and is usually monitored by the managing agency.

Guiding Principles for Eco-labelling

Based on the experiences of successful eco-labelling programs and pertinent ISO work, a series of principles can be identified as being critical to an effective and credible program

1. Voluntary participation: The decisions of manufacturers, importers, service providers and other businesses to participate in an eco-labelling program must be voluntary. Programs should also be designed and operated so that potential industry participants (and other interested parties) can request that eco-labelling categories and criteria be developed for their products.

2. Compliance to environmental and other relevant legislation: A key contributor to the credibility of an eco-labelling program is the nature and extent of program participation requirements, both product-specific and more general conditions. While the main focus of the eco-labelling criteria relates to the environmental aspects and performance of a product being offered, it is important to also address the regulatory compliance of a producer's/provider's facility from which the product is being offered. It is generally accepted that a basic component of industry [environmental] leadership is full compliance with relevant environmental and other legislative requirements. (This compliance requirement may be a licensing condition for program participation rather than a product compliance criterion.) The approach usually taken is to require compliance to legislation applicable on a local/regional scale. This approach acknowledges, and avoids challenging, the varying regulatory requirements that may exist in different jurisdictions. It also avoids imposing on foreign program applicants what could be perceived as "unnecessary obstacles to trade".

3. Consideration of "fitness for purpose" and level of overall performance: Besides legislative compliance, it is also important to address the quality and performance of a product that is to be considered for eco-labelling. The credibility of both the ecolabel and the eco-labelling program could suffer if products bearing the ecolabel don't demonstrate comparable quality and reasonable performance in relation to alternatives. Market and consumer surveys and research have shown that environmental attributes are only one factor considered by consumers in their purchasing decisions, and is usually only factored in once comparable quality and performance has been established.

4. Based on sound scientific and engineering principles: Maintenance of stringent technical requirements based on good ecological science assures consumers that they can trust the ecolabel and licensing applicants that they will be treated fairly. Further, there is a strongly prevailing view that product environmental criteria should be based on indicators arising from life cycle considerations. The rationale is that there is a generally perceived [growing] need to assure consumers, as well as producers and service providers, that all aspects of a product's development, provision, use and end-of-life options have been taken into account.

Eco-labeling innovation cycle

[lx]There is a close relationship between the eco-labeling process and the eco-innovation because it promotes the emergence of new green products and it improves the organizations environmental management strategy. Moreover, eco-labeling process is a "cyclical eco-innovation process in which consumers, firms, governments and institutions interact. Its final purpose is to contribute to the development of sustainable and ecological ways of production and consumption. In this process, consumers' environmental expectations are met; firms increase their created and captured value and enhance their sustainability, and governments and institutions foster cleaner production and consumption. Finally, this process is tangible in the products through the awarding of ecolabels, which are visibly displayed on goods and services".

Benefits of eco-labeling

[lxi]Since its inception 10 years ago, many companies have recognized the benefits of taking on the European Eco-Label scheme. There are currently 135 companies licensed under the scheme and it has been awarded to 21 product groups. These products range from paints, detergents and refrigerators to tourist accommodation. The number is growing and it is the only voluntary scheme which covers products moving across borders. It sets ecological criteria for a range of products and services in a transparent way so that the consumer can make a more informed choice in order to support sustainable consumption patterns. It takes the lifecycle (from cradle to grave) of a product into account e.g. the materials, health implications, and waste factors that impact on the environment.

1. Informing consumer choice Eco-labeling is an effective way of informing customers about the environmental impacts of selected products, and the choices they can make. It empowers people to discriminate between products that are harmful to the environment and those more compatible with environmental objectives. An eco-label makes the customer more aware of the benefits of certain products, for example, recycled paper or toxic-free cleaning agents. It also promotes energy efficiency, waste minimization and product stewardship.

2. Promoting economic efficiency Eco-labeling is generally cheaper than regulatory controls. By empowering customers and manufacturers to make environmentally supportive decisions, the need for regulation is kept to a minimum. This is beneficial to both government and industry.

3. Stimulating market development when customers choose eco-labeled products, they have a direct impact on supply and demand in the marketplace. This is a signal which guides the market towards greater environmental awareness.

4. Encouraging continuous improvement A dynamic market for eco-labeled products encourages a corporate commitment to continuous environmental improvement. Customers can expect to see the environmental impacts of products decline over time.

5. Promoting certification: An environmental certification program is a seal of approval which shows that a product meets a certain eco-label standard. It provides customers with visible evidence of the product's desirability from an environmental perspective. Certification therefore has an educational role for customers, and promotes competition among manufacturers. Since certified products have a prominent logo to help inform customer choices, the product stands out more readily on store shelves. Coveting the logo may induce manufacturers to re-engineer products so that they are less harmful to the environment.

6. Assisting in monitoring: Another benefit of an official eco-labeling program is that environmental claims can be more easily monitored. Competitors and customers are in a better position to judge the validity of a claim, and will have an incentive to do so should a claim appear dubious.

Growing Adaptation to Eco-labelling

The growing use of ecolabels reflects an important change in social attitudes to the environment, and is part of a wider movement towards the use of market-based instruments. Eco-labels are intended to bring significant environmental benefits through their positive influence on consumers` purchasing decisions.

The transparency, access and credibility of ecolabel schemes has emerged as an important concern in the trade and environment context. Transparency at the development stage increases the opportunities for access by exporters. It is also important to provide opportunities for input from the public if the resulting ecolabels are to command credibility from consumers. The design of ecolabels need to take account of the GATT and the Technical Barriers to Trade Agreement. It is also of vital importance that schemes should be rigourous and even-handed in the testing and certification of products for awarding the ecolabel. Technical assistance to developing countries is needed in a number of areas, including environmental testing, environmental auditing, life cycle analysis, certification and participation in international technical committees.

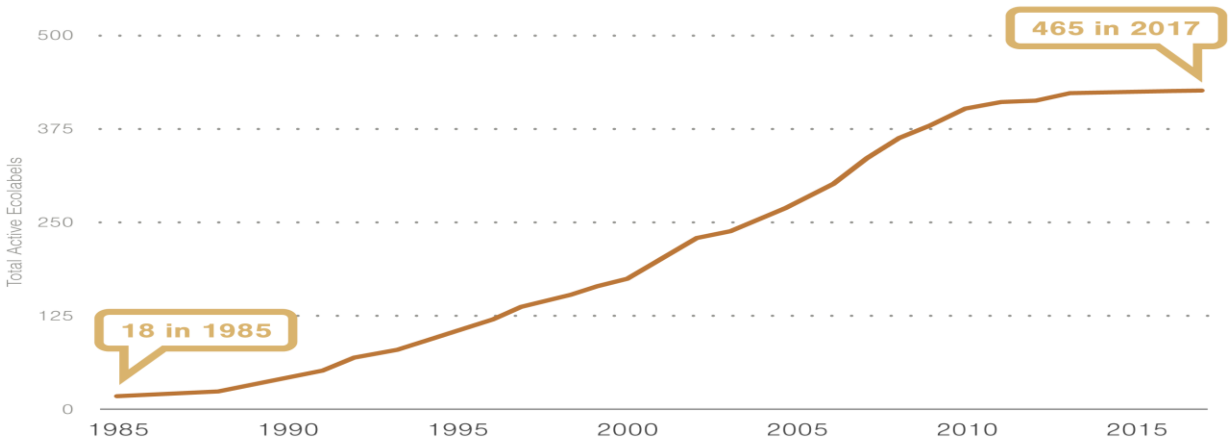


Fig 2.17 Food Ecolabelling in North America

To tackle the trade issues raised by non-product related issues in ecolabels, it could be useful to explore a proposal for identifying sensitive traded products on which it is particularly important to involve developing countries in ecolabel proposals. In the longer term, the most fruitful approach could be to examine the scope for mutual recognition or equivalence between eco-labelling schemes. A common set of good practice principles would be needed to provide a basis for equivalence.

Summary Points

1. Consumption patterns before the modern industrialization era was need based and limited to accessibility of local resources.
2. Global consumerism culture has been fueled over the last few decades by the marketing, advertising, and free trade.
3. Consumerism culture has become more visible and growing in Indian context over since liberalization policies, and which also rapid changes in lifestyle practices.
4. Consumer moment in India upto the 80’s was more focused on quality, affordability, and availability of products. County witnessed strong consumerism moments in the metros.
5. Ghandian philosophy continues its relevance on developing self-sustaining, decentralized circular economy (Gram Swaraj).
6. Consumerism culture has led to unsustainable consumption and production patterns. Unsustainable production and production-consumption practices and they cumulatively

escalates depletion of virgin natural resources, and simultaneously aggravates the rate of degradation.

7. Consumer education and growing sensitized consumers globally has empowered consumers into being more informed, and demand responsible production practices from manufactures.
8. Growing enhanced responsible consumer behavior has created a demand for ecologically accountably produced and sourced products. Further, it paves way for improving individual and collective consumer behaviour.
9. Increasing trend in demand for Eco-labelled products indicates behavioral and attitude changes among the producers and consumers.
10. Changing in behaviour in consumers and producers has a cross cutting linkage to SDG goals SDG12, SDG 13 (Climate Action), and SDG 11 (Sustainable Cities and Communities).

To do Activities

a. Identify production practices in agriculture and animal husbandry to meet demands of consumption centered markets.
b. Identify products in rural economy that has scope for Eco-Labelling, and prepare a case study of how Eco-labelling has potential to increase the products' market share.
c. Identify gaps and opportunities to develop communication strategies to enhance the marketability of Eco-labelled products.

Chapter3 - Use & Throw Culture

Introduction

Changing lifestyles is a manifestation of industrialization, and subsequent urbanization. This phenomenon gained its momentum with rapid urbanization due to liberalization and free trade, under the globalization policies. Interestingly the modern society got trapped under 'Zero Maintenance' syndrome, which brought consumption and production systems patterns on a linear model.

Consequent emergence of Use and Throw culture. Increased scales of mass production and consumption and use of single use materials over a period of time created unmanageable challenges in managing the generating waste - be it gaseous, liquid and solid. The critical challenge lies in handling bon-biodegradable hazardous waste. The bio accumulation of hazardous waste chemicals in addition to contaminating the natural systems, is entering into the food chain, threatening all life-forms. This challenge is surpassing the Earth's assimilation capacity.

The presented problems emerged through multi-faced anthropogenic activities, and addressing these challenges calls for multi-disciplinary approaches, opening opportunities for social engineering, research and development, human resource development, innovation, and entrepreneurship – ensuring sustainable economic development, and reduced environmental degradation; thus paving way for holistic productive environment.

Objective

The aim of the module is to sensitize on the responsible behavior of the consumer towards the Earth's resources and environment. To sensitize on sustainable use of resources, through transformation of social behavior. Further, enhance the relevance and impotence of resource literacy and zero waste management practices, including plastic free environments.

3.1 - Use & Throw Culture

It is commonly asserted, in developed countries, at least, that there is a crisis of waste and a failure of waste management policy. Moreover, the crisis is said to arise from the fact that contemporary consumer societies have developed a 'disposable' mentality in a 'throwaway' culture, and now discard items that, once, would have been reused, recycled or held in stewardship by our ancestral bricoleurs. These claims are so commonplace, so much a part of the commonsense of public and private life, that few have examined whether or not they are true and, with some exceptions, little evidence has been provided to establish their veracity. In fact, these claims, for the United Kingdom at least, have less evidential foundation than might be expected .[lxii]They have the effect of misrepresenting what is happening in relation to waste in the contemporary world and they also gloss the past. In the simplest terms, it is not proven that contemporary consumers waste more than their historically miserly counterparts. Nor is it true that, in the past, our grandparents and their grandparents 'stewarded' objects and reused, recovered or recycled significantly more than happens today. Instead, the available evidence appears to show that contemporary consumers waste little more than their historical counterparts. This fact goes against the grain of both public and expert opinion but there are two sets of questions that can help to clarify why the consumerism equals waste crisis argument stands in need of a critical assessment. First, there is an important conceptual difference between talking about what people throw away and talking about what people waste. If one society deposits more unused materials on the environment than another one, does this mean it is more wasteful? Or does it mean that it processes more in the first place – so that there is simply a greater quantity of materials passing through its various industrial and domestic sectors? Is paper or plastic in a landfill more wasteful than offal or ash on the street, for example? It is far from clear that, as a proportion of what is produced and consumed, present-day consumers squander any more than any historical society has ever done. [lxiii]This is not to say that larger and/or more toxic depositions have no greater environmental impact but that is a rather different proposition to the claim that contemporary consumers are inherently more profligate. Second, by and large, the claim that contemporary societies are unusually wasteful compared to the past is based on an analysis only of municipal wastes and their relation to consumer discards. The time-frame for the analysis has tended to be short – where any time-frame is referenced at all less than a decade is typical. However, looking at patterns of twentieth century household waste suggest that today's consumers are not necessarily as profligate in relation to the past as contemporary commentary tends to imply.

The *'Throw-away Society'* or '*Use and Throw Culture'* describes a critical view of overconsumption and excessive production of short-lived or disposable items over durable goods that can be repaired.

History of Use and throw Culture

[lxiv]The cradle of the throwaway culture, according to Toffler (1970), is the Americas. From America, it has spread to Europe, and in the recent years ultimately globalised. Toffler (1970) asserts that the philosophy has been perpetrated by the increasing philosophy of socio-cultural transience and transformation. This argument reaches to the notion of globalisation. He argues that the contemporary society is increased the propensity towards impermanence, modularism, technically innovation and organisation. It is based more towards production of goods than any other period in the annals of the history of humanity "not meant to last". This can be seen in aspects like architecture and engineering. In the past, people built to last. New York, according to Toffler has been a "city without history", to exemplify this conception. Technology is ever changing such that obsolescence is on the faster increases than any other time in the past.

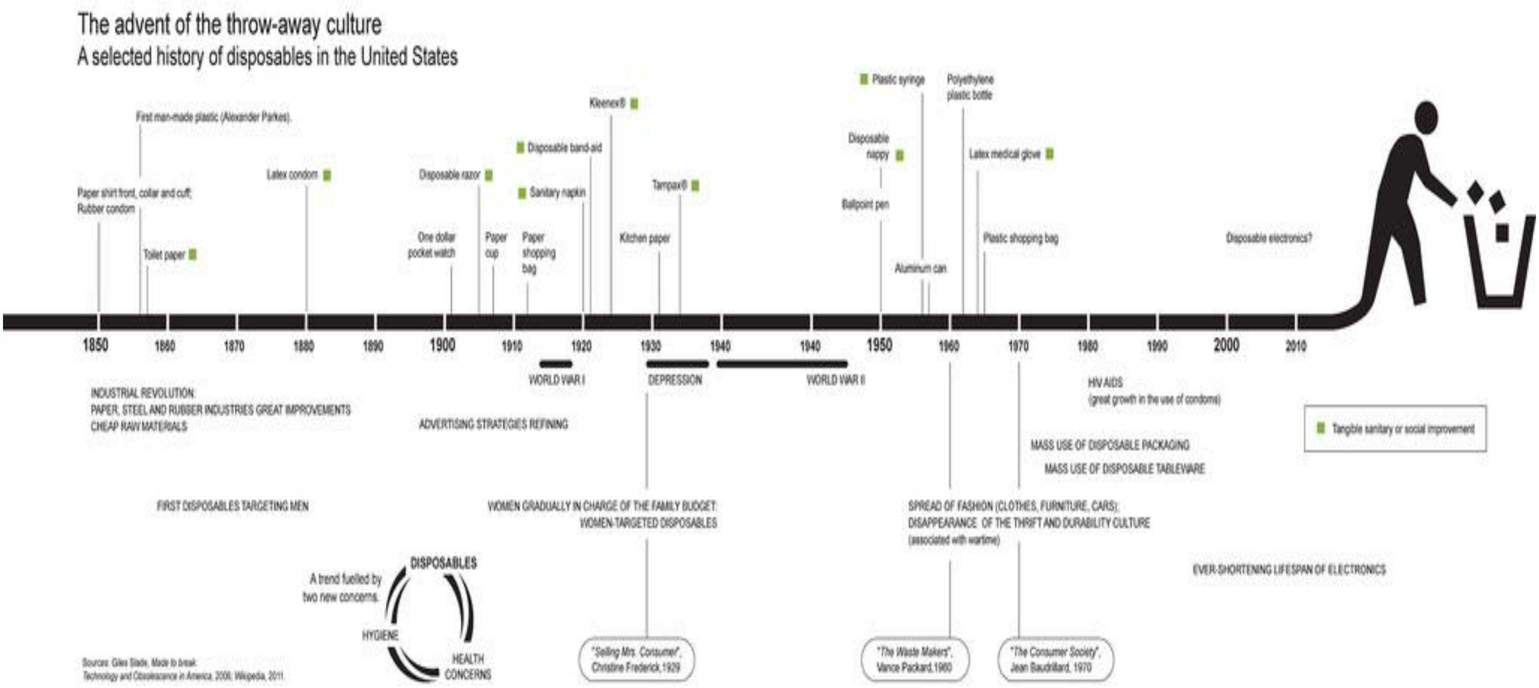


Fig 3.1 History of throw-away culture

This brings into perspective the notion of 'fashionableness', which is marked by the basic characteristics of a "…buy, use and throwaway society" (Toffler 1970:56). The rise of rentalism and hiring services reinforces the modishness of throwaway and modularism. This explains why the throwaway culture is much more than a simple physical disposal of waste issue. Toffler typifies the whole phenomenon by citing its dynamics as portrayed by Japan and France.

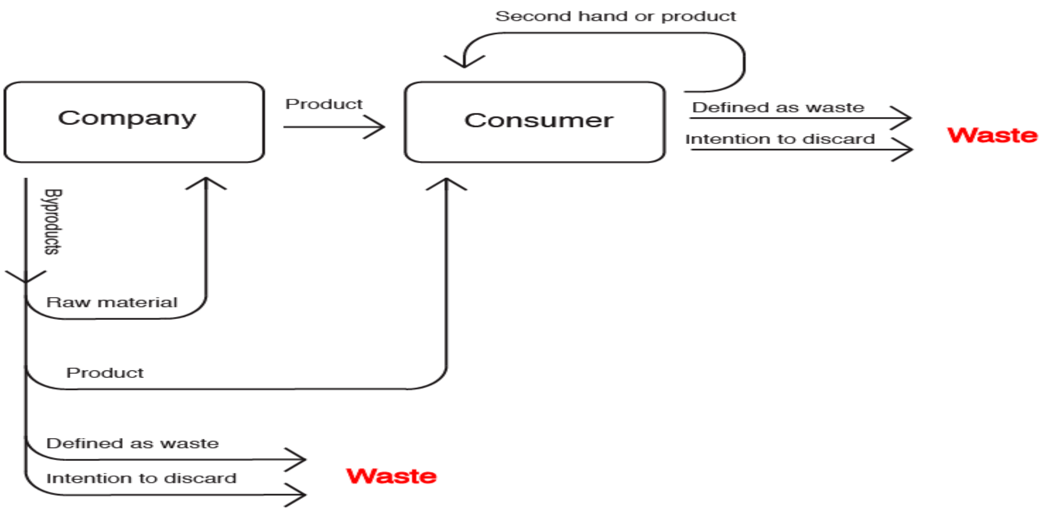


Fig 3.2 – Use and throw Process

He writes that in Japan, "…throw-away tissues are so widely used that cloth handkerchiefs are regarded as old fashioned, not say unsanitary. And even in France, disposable cigarette lighters are commonplace.

From cardboard milk containers to the rockets then power space vehicle, products created for long-term or one-time use are becoming more numerous and crucial to our way of life…But to spread of disposability through the society implies decreased durations in man thing relationships. Instead of being linked with a single object over a relatively long span of time, we are linked for brief periods with the succession of objects that supplant it".

The throwaway culture has critical psychological roots and effects. One effect is that respect to property is changed. Toffler (1970) explains the way the fabric of social experience comprises five relationships. These are people, organisations and ideas and time. The "situation" goes with the changing attitudes of "things", which people will assume. Transformation moves with technology, super-industrialism and standardisation (i.e. uniformitarianism associated with the minimum set values). These are key features indicating that social and economic transformation in society is an irrefutable reality.

Socio-Economic Causes of Use and Throw Culture

An important part of the problem with the Use and Throw Culture is that it is rooted in a family of ideas about the 'crisis of waste' that brings together a moral critique and a sociological analysis of consumerism. The moral critique pays attention to escalating demand, high product turnover, and built-in obsolescence in a society increasingly oriented towards convenience. The sociological analysis pays attention to economic and cultural changes (particularly in the post-World War period) relating to levels of affluence, patterns of taste and industrial innovation.

The post-war period has seen a dramatic increase in the production of waste, reflecting unprecedented global levels of economic activity. The increase in the waste stream can be attributed to a number of factors: rising levels of affluence; cheaper consumer products; the advent of built-in obsolescence and shorter product life-cycles; the proliferation of packaging; changing patterns of taste and consumption; and the demand for convenience products.

1. There are several possible explanations for the apparent growth rate, only one of which demonises consumers and their throwaway mentality. The simplest explanation for increased amounts of household waste may be that there has been an increase in the population during the period.
2. A second explanation might be that people have become relatively wealthier across the period–either through absolute gains in monetary income or through relative declines in prices. In both cases, increasing amounts of waste might reflect increasing quantities of goods being brought into the house as a consequence of increasing personal wealth.
3. A third explanation might be that there has been no change in population, no significant increase in wealth but changes in disposal practices. In this case, without any increased material 'inputs,' households have consumed less and less, and discarded more and more, of those materials. If this be the case, it would indeed demonstrate that the throwaway mentality really had taken hold and in turn would support the moral critique of the effects of consumerism.

In addition to socio-economic and cultural push to the use and throw culture there are several market practices that further supplement and induce this culture.

Market Drivers of Use and Throw Culture

[lxv]Since the mobile phone handset market reached saturation in Europe and the United States about a decade ago, we have chosen not to wait for our devices to fail. Almost all new phones purchased are "upgrades", replacing functioning phones simply for reasons of fashion or for technological

additions that many of us rarely use, and which could otherwise easily be achieved through software upgrades to existing handsets. Indeed, most phone companies compete for business by automatically upgrading customers' phones every year. And these smart phones use mined resources from some of the most ecologically sensitive areas of the world, as a recent Friends of the Earth campaign points out.

- Developing nation like India, a mobile phone that is more than two years old is considered obsolete and, increasingly, consumers prefer to just buy a new device rather than repair a broken screen or a malfunctioning motherboard.
- Apparel companies sell far larger amounts of new clothes than they recycle old ones, and have struggled to convince consumers to bring old clothes to the store.
- Human activities largely driven by our society's demand for having more than we need, resulting in the highest ever annual global waste generation on record
- Affordability for tech items has increased considerably leading to frequent buying rather than repairing and reusing.
- Repairing has become a thing of the past; it's more convenient and less expensive to simply upgrade
- Competition is pushing big corporations behind electrical goods manufacturing to outdo one another in the name of profits and market share.

3.2 Disposable products

A disposable (also called disposable product) is a product designed for a single use after which it is recycled or is disposed as solid waste. The term often implies cheapness and short-term convenience rather than medium to long-term durability. [lxvi]The term is also sometimes used for products that may last several months (e.g. disposable air filters) to distinguish from similar products that last indefinitely (e.g. washable air filters). The word "disposables" is not to be confused with the word "consumables" which is widely used in the mechanical world. In welding for example, welding rods, tips, nozzles, gas, etc. are considered to be "consumables" as they last only a certain amount of time before needing to be replaced.
Disposable products are most often made from paper, plastic, cotton, or polystyrene foam. Products made from composite materials such as laminations are difficult to recycle and are more likely to be disposed of at the end of their use. The major contributors to disposable products globally are Packaging and Food service industry disposables and Medical & hygiene products.

Packaging & Food Service Industry Disposables

Packages are usually intended for a single use. The waste hierarchy call for minimization of materials. Many package forms and materials are suited to recycling although the actual recycling percentages are relatively low in many regions. Reuse and repurposing of packaging is increasing but eventually, containers will be recycled, composted, incinerated, or landfilled.

There are many container forms such as boxes, bottles, jars, bags, etc. Materials include paper, plastics, metals, fabrics, composites, etc. Packaging materials are some of the most ubiquitous and easily recognizable items people use. Packaging includes plastic bottles, metal cans, corrugated cardboard boxes and many more materials. Production and disposal of these materials is crucial in making economic and environmentally conscious decisions. With the constantly aggravating global pollution and climate change, the need for a fast switch to sustainable materials, resources and technologies, is growing. With the growing challenges of non-biodegradable materials, manufactures globally are exploring Sustainable Packaging Strategies.

Sustainable Packaging

[lxvii]Packaged food & beverages, and personal care companies are demanding eco-friendly packaging materials that are also visually appealing to consumers. This has pushed vendors to introduce innovative products and the use new technologies in their manufacturing. They are looking for high-performing packaging options that permit them to retain low manufacturing costs. Despite growing consumer preference for sustainable packaging, designing with the aim to minimize environmental impact remains a real challenge. Additionally, numerous companies continue to compromise with their packaging. Encouraging the shift in packaging construction towards more lightweight or efficient materials, helps companies save money while decreasing the amount of waste generated.

Fig 3.3- Sustainable Packing Categories

[lxviii]Sustainable packaging is the development and use of packaging which results in improved sustainability. This involves increased use of life cycle inventory (LCI) and life cycle assessment (LCA) to help guide the use of packaging which reduces the environmental impact and ecological footprint. It includes a look at the whole of the supply chain: from basic function, to marketing, and then through to end of life (LCA) and rebirth. Additionally, an eco-cost to value ratio can be useful. The goals are to improve the long term viability and quality of life for humans and the longevity of natural ecosystems. Sustainable packaging must meet the functional and economic needs of the present without compromising the ability of future generations to meet their own needs. Sustainability is not necessarily an end state but is a continuing process of improvement.

Sustainable packaging is a form of packaging that utilizes manufacturing methods or materials that have a low impact on the environment. In addition, several players are also focused on developing niche products in the market. Rapid growth of this market has also resulted in creating further skilled job opportunities in major hubs spread across North America, and Asia Pacific. Sustainable packaging is developing as an important industry because of the problems faced due to pollution generated by packaging, especially in the developing countries. Major developments in sustainable packaging techniques in Asian countries are considered, and the present and forecast market size of the industry is provided.

Sustainable packaging involves the use of manufacturing methods and materials for packaging of goods that have a low impact on the environment and energy consumption. Green or sustainable packaging uses environment-sensitive methods, including energy efficiency, recyclable and biodegradable materials, and reusability. Retailers and consumer packaged goods companies have devoted more attention towards developing sustainable products, mainly in response to customers' evolving expectations. By application, food and beverage is the largest application segment and is expected to continue dominating the market in the future. The material is gaining popularity among industries such as food & beverage, healthcare, and personal care, owing to the growing environment concerns and the increasing need for reducing the use of toxic materials.

Disposable Medical & Hygiene Products

Medical and surgical device manufacturers worldwide produce a multitude of items that are intended for one use only. The primary reason is infection control; when an item is used only once it cannot transmit infectious agents to subsequent patients. Manufacturers of any type of medical device are obliged to abide by numerous standards and regulations. ISO 15223: Medical Devices and EN 980 cite that single use instruments or devices be labelled as such on their packaging with a universally recognized symbol to denote "do not re-use", "single use", or "use only once".

Health-care activities protect and restore health and save lives. But what about the waste and by-products they generate?

- Of the total amount of waste generated by health-care activities, about 85% is general, non-hazardous waste comparable to domestic waste. The remaining 15% is considered hazardous material that may be infectious, chemical or radioactive.
- Of the total amount of waste generated by health-care activities, about 85% is general, non-hazardous waste.
- The remaining 15% is considered hazardous material that may be infectious, toxic or radioactive.
- Every year an estimated 16 billion injections are administered worldwide, but not all of the needles and syringes are properly disposed of afterwards.
- Open burning and incineration of health care wastes can, under some circumstances, result in the emission of dioxins, furans, and particulate matter.
- Measures to ensure the safe and environmentally sound management of health care wastes can prevent adverse health and environmental impacts from such waste including the unintended release of chemical or biological hazards, including drug-resistant microorganisms, into the environment thus protecting the health of patients, health

workers, and the general public.

- Lack of awareness about the health hazards related to health-care waste, inadequate training in proper waste management, absence of waste management and disposal systems, insufficient financial and human resources and the low priority given to the topic are the most common problems connected with health-care waste. Many countries either do not have appropriate regulations, or do not enforce them.

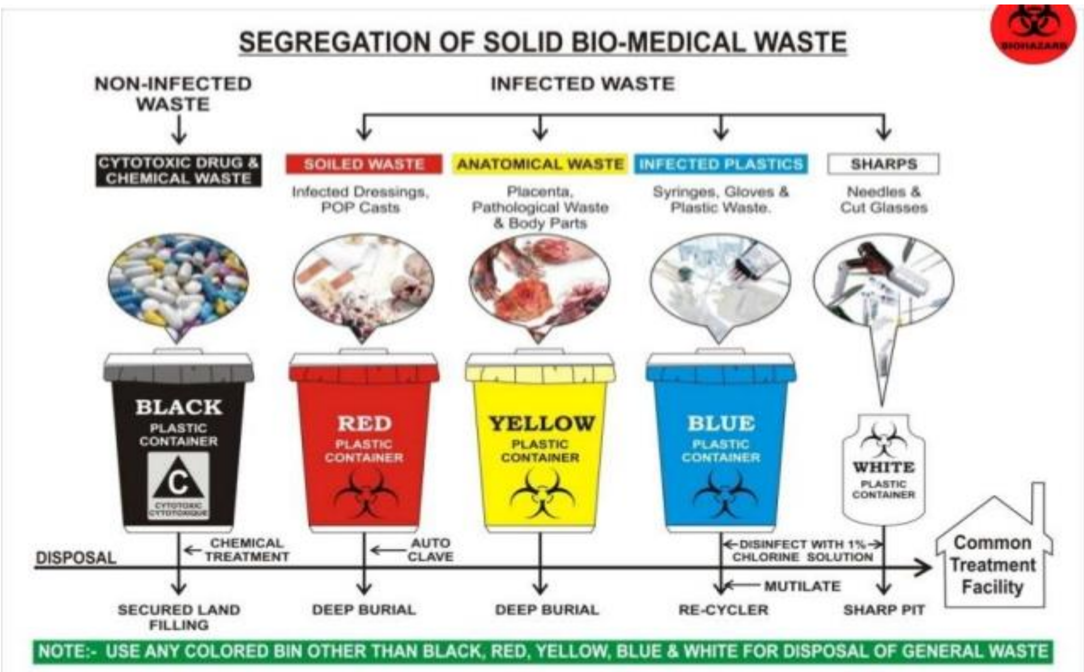


Fig 3.4 – Medical Waste Segregation

•**Types of Medical waste:** Waste and by-products cover a diverse range of materials, as the following list illustrates

•**Infectious waste:** waste contaminated with blood and other bodily fluids (e.g. from discarded diagnostic samples),cultures and stocks of infectious agents from laboratory work (e.g. waste from autopsies and infected animals from laboratories), or waste from patients with infections (e.g. swabs, bandages and disposable medical devices);

•**Pathological waste:** human tissues, organs or fluids, body parts and contaminated animal carcasses;

•**Sharps waste:** syringes, needles, disposable scalpels and blades, etc.;

•**Chemical waste:** for example solvents and reagents used for laboratory preparations, disinfectants, sterilants and heavy metals contained in medical devices (e.g. mercury in broken thermometers) and batteries;

•**Pharmaceutical waste:** expired, unused and contaminated drugs and vaccines;

•**Cyctotoxic waste:** waste containing substances with genotoxic properties (i.e. highly hazardous substances that are, mutagenic, teratogenic or carcinogenic), such as cytotoxic drugs used in cancer treatment and their metabolites;

•**Radioactive waste:** such as products contaminated by radionuclides including radioactive diagnostic material or radio therapeutic materials; and

•**Non-hazardous or general waste:** waste that does not pose any particular biological, chemical, radioactive or physical hazard.

The major sources of health-care waste are

- Hospitals and other health facilities
- Laboratories and research centres
- Mortuary and autopsy centres
- Animal research and testing laboratories
- Blood banks and collection services
- Nursing homes for the elderly

High-income countries generate on average up to 0.5 kg of hazardous waste per hospital bed per day; while low-income countries generate on average 0.2 kg. However, health-care waste is often not separated into hazardous or non-hazardous wastes in low-income countries making the real quantity of hazardous waste much higher.

Health Risks[lxix]Health-care waste contains potentially harmful microorganisms that can infect hospital patients, health workers and the general public. Other potential hazards may include drug-resistant microorganisms which spread from health facilities into the environment.Worldwide, an estimated 16 billion injections are administered every year. Not all needles and syringes are disposed of safely, creating a risk of injury and infection and opportunities for reuse.

[lxx]Injections with contaminated needles and syringes in low- and middle-income countries have reduced substantially in recent years, partly due to efforts to reduce reuse of injection devices. Despite this progress, in 2010, unsafe injections were still responsible for as many as 33 800 new HIV infections, 1.7 million hepatitis B infections and 315 000 hepatitis C infections.

A person who experiences one needle stick injury from a needle used on an infected source patient has risks of 30%, 1.8%, and 0.3% respectively of becoming infected with HBV, HCV and HIV. Additional hazards occur from scavenging at waste disposal sites and during the handling and manual sorting of hazardous waste from health-care facilities. These practices are common in many regions of the world, especially in low- and middle-income countries. The waste handlers are at immediate risk of needle-stick injuries and exposure to toxic or infectious materials.

In 2015, a joint WHO/UNICEF assessment found that just over half (58%) of sampled facilities from 24 countries had adequate systems in place for the safe disposal of health care waste. Adverse health outcomes associated with health care waste and by-products also include

- Sharps-inflicted injuries;
- Toxic exposure to pharmaceutical products, in particular, antibiotics and cytotoxic drugs released into the surrounding environment, and to substances such as mercury or dioxins, during the handling or incineration of health care wastes;
- Chemical burns arising in the context of disinfection, sterilization or waste treatment activities;
- Air pollution arising as a result of the release of particulate matter during medical waste incineration;
- Thermal injuries occurring in conjunction with open burning and the operation of medical waste incinerators; and
- Radiation burns.

Environmental Impact

Treatment and disposal of healthcare waste may pose health risks indirectly through the release of pathogens and toxic pollutants into the environment.

- The disposal of untreated health care wastes in landfills can lead to the contamination of drinking, surface, and ground waters if those landfills are not properly constructed.
- The treatment of health care wastes with chemical disinfectants can result in the release of chemical substances into the environment if those substances are not handled, stored and disposed in an environmentally sound manner.
- Incineration of waste has been widely practiced, but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants into the air and in the generation of ash residue. Incinerated materials containing or treated with chlorine can generate dioxins and furans, which are human carcinogens and have been associated with a range of adverse health effects. Incineration of heavy metals or materials with high metal content (in particular lead, mercury and cadmium) can lead to the spread of toxic metals in the environment.
- Only modern incinerators operating at 850-1100 °C and fitted with special gas-cleaning equipment are able to comply with the international emission standards for dioxins and furans.

- Alternatives to incineration such as autoclaving, microwaving, steam treatment integrated with internal mixing, which minimize the formation and release of chemicals or hazardous emissions should be given consideration in settings where there are sufficient resources to operate and maintain such systems and dispose of the treated waste.

Strategies for Sustainable Management of Disposable Medical & Hygiene Products

The management of health-care waste requires increased attention and diligence to avoid adverse health outcomes associated with poor practice, including exposure to infectious agents and toxic substances.

Key elements in improving health-care waste management are

- Promoting practices that reduce the volume of wastes generated and ensure proposer waste segregation;
- Developing strategies and systems along with strong oversight and regulation to incrementally improve waste segregation, destruction and disposal practices with the ultimate aim of meeting national and international standards;
- Where feasible, favouring the safe and environmentally sound treatment of hazardous health care wastes (e,g, by autoclaving, microwaving, steam treatment integrated with internal mixing, and chemical treatment) over medical waste incineration;
- Building a comprehensive system, addressing responsibilities, resource allocation, handling and disposal. This is a long-term process, sustained by gradual improvements;
- Raising awareness of the risks related to health-care waste, and of safe practices; and
- Selecting safe and environmentally-friendly management options, to protect people from hazards when collecting, handling, storing, transporting, treating or disposing of waste.

Government commitment and support is needed for universal, long-term improvement, although immediate action can be taken locally.

Single Use (Disposable) vs. Reusable Cups – Analysis

Is investing in a reusable cup or bottle really going to lower your environmental footprint?This is a valid question and there has been confusion around this topic as there are many differing opinions.

1. What's the environmental impact of disposable cups?
2. What's the environmental impact of reusable cups?
3. When are reusable alternatives better than single use cups?

The Basics of Comparing Single Use Vs. Reusable[lxxi]

Varying opinions on whether disposable cups are worse or better for the environment than reusable alternatives stem from unfair comparisons.

A few reasons why people may be comparing apples to oranges

1. **Types** - different types of disposable cups (paper, plastic, styrofoam) have varying impacts. Likewise, so do their reusable counterparts. This makes it difficult to make blanket statements like "all disposable cups are worse than reusable alternatives"
2. **Focus** - you can paint a different picture depending on which aspect of environmental impact you're focusing on. Energy use, natural resource use, pollution, and emissions, are just a few of the different areas you can compare. To be fair, you have to consider the complete environmental impact of disposable vs reusable, not just one aspect.
3. **Other** - Other variables such as the technology used to manufacture the cup or how long it traveled to get the place of sale also change the environmental impact.

They key indicators of environmental impact: There are several variables to compare when it comes to rating the overall environmental impact of a product. Here are the main 3 areas and some of the considerations of each

- **Production** - What it takes to make the product
    - Input of energy and natural resources
    - Transportation of raw materials and finished product
    - Emissions and other pollutants from manufacturing
- **Use** - How use of the product impacts humans or the environment
    - Impact on human health
    - Lifespan of the product
    - Environmental impact of use (if any) - example: washing of reusable cups
- **Post Use** - How disposal of the product impacts the environment
    - Pollution of natural environment
    - Emissions from disposal (gasses from breakdown in landfill or incineration)
    - Cost of recycling

The total impact of a product can be calculated using our simplified formula

Total Environmental Impact = Cost of Production + Cost of Use + Cost of Post Use

The Key Performance Indicators[lxxii]

There are also several different types of environmental impact. The most common types and the causes they are linked to include

Emissions - global warming, air pollution

Natural Resource Use - deforestation, biodiversity loss, global warming

Pollution - biodiversity loss, degradation of natural environment

Some people may weight one factor as more important than another depending on their opinions of which environmental issue is most pressing. The most common comparison for environmental impact is energy used to create, distribute, and dispose of the product.

Energy input is considered to be the primary indicator of environmental impact because it is tied to almost all other factors. It takes natural resources such as coal to create energy and once burned it contributes to emissions that fuel global warming. In this comparison of disposable vs reusable cups we will draw from several studies about energy use in each phase: production, use, and post use.

It's important to note that there are other considerations when buying a product such as the social responsibility of the company producing it. I'll touch on these considerations in my summary.

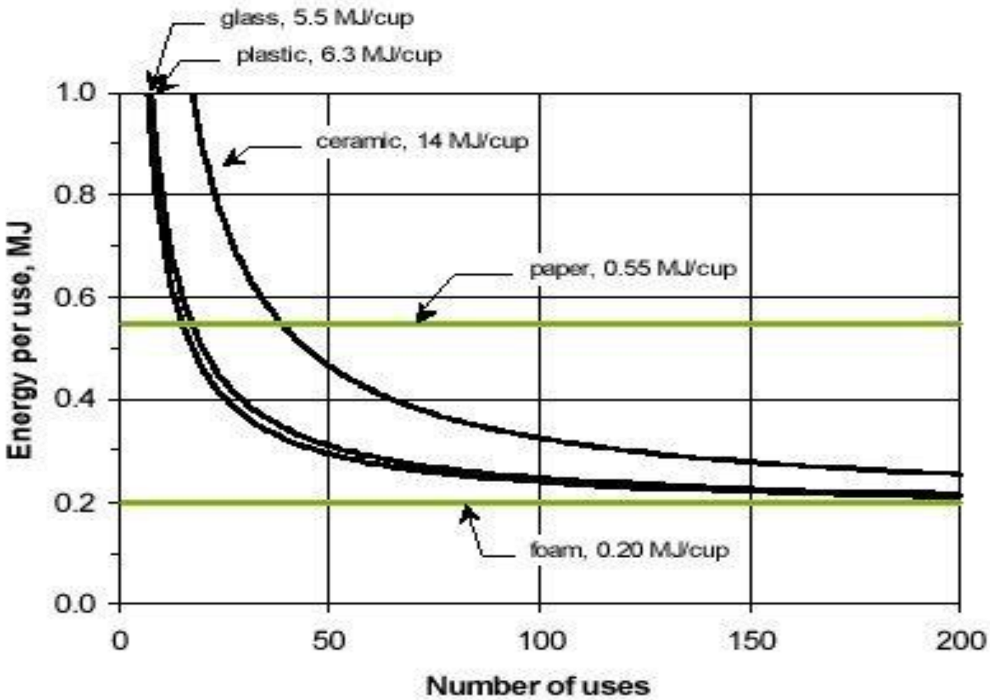


Fig3.5 Energy Consumption in Production

Cost of Production: In general, producing one disposable cup has a lower environmental impact than producing one reusable cup or bottle.Measurement of Energy Input Needed (kJ/Cup) to roduce 1 Unit.

Producing a Styrofoam or paper cup requires much less energy input than reusable alternatives such as plastic, glass, or ceramic.Disposable cups are smaller, lighter, and easier to make, while their counterparts require more input of resources and energy.

Proponents of single use cups may stop here and claim that disposables are more energy efficient and therefore more environmentally friendly. But the most critical evaluation happens in the next two phases: Use and Post Use.In general, when comparing 1 cup to 1 reusable cup, the production of disposable cups is in fact more ecofriendly.

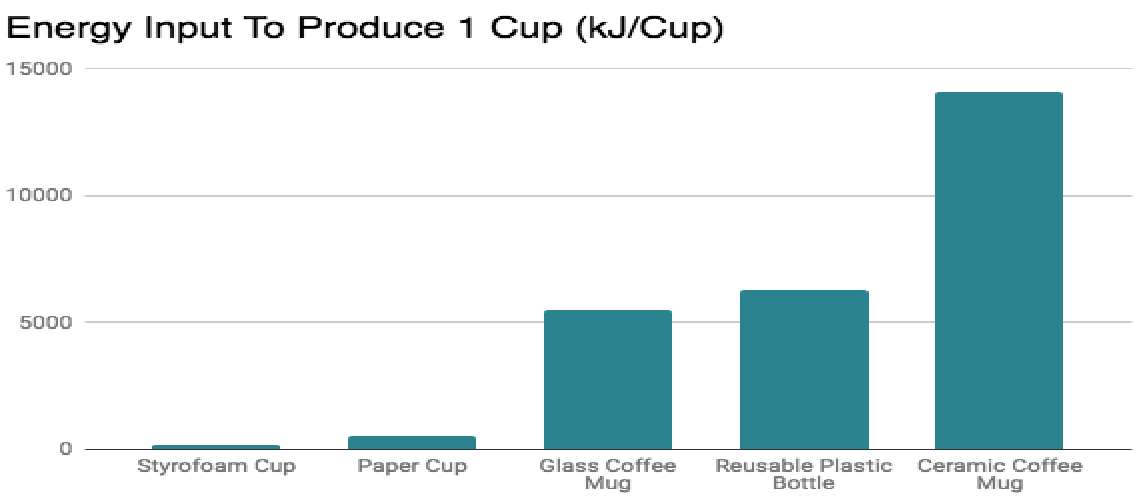


Fig 3.6 Energy Consumption in Production per Cup

Key Considerations - the Wash

A key factor in this aspect of the environmental impact of disposable vs reusable comes down to washing.While disposables have no energy input necessary for their use, reusable do. In order to continue reusing a glass, plastic, or ceramic cup it needs to be washed which will contribute to its overall environmental impact.

Of course, there are different ways to wash cups and some are more eco friendly than others.In general, washing by hand is more energy efficient than using a dishwasher. And washing with cold water is more energy efficient than washing with hot water.The safest estimate to use is the energy use of a common household dishwasher.

Cost of Disposal (post use)

Are disposables recyclable? Disposable cups are disposed of in mass and the most common type, used for coffee, are difficult to recycle. The vast majority of paper cups we use daily for takeaway drinks have a plastic lining in them that prevents to paper cup from becoming saturated and falling apart.This plastic lining must be separated from the paper in the recycling process which makes recycling them difficult and costly. In fact, most recycling centers are not equipped to process them.

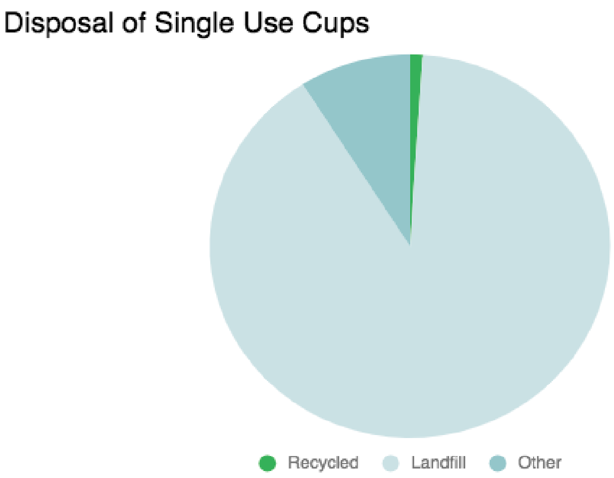


Fig 3.7 Disposal of Single Use Cups (1% Recycled)

It's difficult to calculate the cost of disposing single use cups because of various scenarios. However, we should consider the following

- Collecting and transporting used cups is energy intensive (think trash trucks)
- Once in a landfill cups may breakdown slowly in the right conditions but their plastics will take hundreds of years resulting in landfills that are wastelands
- Greenhouse gas release from landfills is a major contributor to global warming
- Incinerating disposable waste will recoup some of the energy but also results in emissions that contribute to global warming and air pollution
- The sheer volume of disposable cups thrown away on a daily basis is hard to fathom (Starbucks alone produces 4 Billion each year)

The Bottom-line

Reusable cups have a longer lifespan so their overall disposal impact is much lower than single use cups. Most reusable cups can be recycled. Glass and ceramic are less of a threat to the natural environment because they will break down over time and do not contain synthetic chemicals, unlike styrofoam or the plastic lining of paper cups which do not biodegrade. Disposal of single use cups poses other threats such as the cost of waste collection and the accumulation of these products in our water bodies, when they are not taken to the landfill or incinerated.

3.3 Resource Efficiency Strategy

In the next decades the extraction and use of natural resources in India will significantly rise due to the country's population growth and economic development. As many resources are finite, the growing demand is expected to result in considerable challenges, such as rising raw material prices, irregular supply and potentially negative effects to the environment. One way to tackle these problems is through enhanced resource efficiency and making better use of secondary raw materials.

Resource efficiency is a strategy to achieve themaximum possible benefit with least possible resource input. Fostering resource efficiency aims at governing and intensifying resource utilisation in a purposeful and effective way. Such judicious resource use brings about multiple benefits along the three dimensions of sustainable development - economic, social and environmental. Sustainable Development, by its very definition, must also take into consideration three critical aspects related to resource equity and access. Firstly, that all human beings, regardless of their location in the global socio-economic-environmental matrix, must have access to a minimum level of income and environmental quality for a dignified sustenance. Secondly, it also must ensure that the benefits, burdens and risks of resource use and conservation be equitably distributed.Thirdly, resource efficient production and consumption practices must take into account the needs of future generations by conserving access to resources.

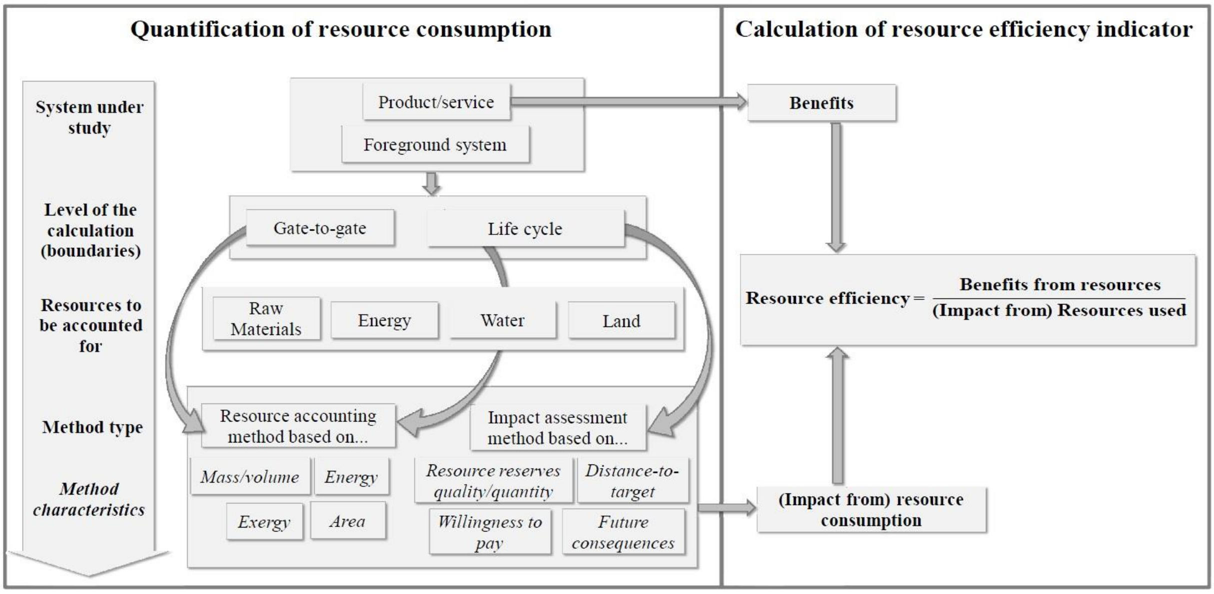


Fig3.8 Resource Efficiency Strategy

Resource Efficiency Principles

Natural resource management should be shaped by two guiding principles

• [lxxiii]Maximizing the value contributed by natural resources to overall human wellbeing – by raising resource efficiency/productivity ("doing more with less")

– Ensuring equitable access to resources, including for future generations ("fairness in distribution")

– Using appropriate decision tools ("lifecycle analysis")

• Minimizing the overall costs to society of consuming natural resources

– For the economy by efficient technologies, reducing waste, the 5Rs (Reduce, Reuse, Recycle, Refuse, Recover)

– For the community by fair access, burden sharing and reduced conflict

– For the ecosystem by minimizing pollution and maximizing circular loops

Based on these principles, policy measures need to be formulated and their use integrated along four perspectives: the stages of the lifecycle, selected sectors, selected materials, and cross-cutting measures. To begin with, India could focus on designing policy instruments (including the cross-cutting instruments such as sustainable public procurement, standards, eco-labelling and certification) for promoting resource efficiency in the use of critical materials in the hotspot sectors (key industrial and strategic sectors) of the economy. There will also need to be multi-stakeholder involvement including cross-industry collaboration as well as collaboration among public, private, academic, and non-profit institutions, and information exchange to harmonize the interests and constraints of the different groups involved in these sectors along the different life-cycle stages.

Existing Policies as a Foundation for a Resource Efficiency Strategy

In India, there are many existing policies influencing resource use at different lifecycle stages starting from mining to designing, followed by manufacturing, consumption and ultimately end-of-life management (disposal or recycling). However, their design, emphasis, integration or implementation is often suboptimal in terms of achieving RE goals.

[lxxiv]**At the mining stage**, the National Mineral Policy already includes zero-waste mining as a national goal and emphasizes the need to upgrade mining technology. In addition, there is a need to promote extraction of associated metals (Tin, Cobalt, Lithium, Germanium, Gallium, Indium, etc.) along with major metals like Copper, Lead and Zinc to enhance resource efficiency in the sector. Just as the Steel Policy aims to increase extraction rate from present 93.5% to 98%, there is a need to increase efficiency in extraction of other minerals to reduce mining and associated environmental impacts.

At the design stage, policies like the National Housing and Habitat Policy, 2007 and the Pradhan MantriAwasYojana (PMAY), 2015 emphasize on developing appropriate ecological design standards for building components, materials and construction methods and there is a need to introduce such components in other sector policies. The Department of Science and Technology, Ministry of Science and Technology, is promoting R&D related to waste management and there is a need to further enhance funding for RE and Secondary Raw Materials (SRM) related R&D. Further, there is a need to promote voluntary standards, like Green Reporting Initiative and ISO 14062:200212 to develop and strengthen design initiatives for improving resource efficiency and promoting use of secondary raw materials across sectors.

[lxxv]**At the manufacturing stage**, flagship programmes like “Make in India” that provide special assistance to energy efficient, water efficient and pollution control technologies through Technology Acquisition and Development Fund (TADF) can promote RE and SRM approaches as well. Industrial and sectoral policies can include promotion of industrial symbiosis (where waste from one industry is raw material for another), process efficiency programs and use of recycled materials in manufacturing.

While an eco-labelling scheme from MoEFCC is in place, its impact has been rather limited; there is a need to include provisions for preferential procurement of eco-labelled products through Green Procurement Policies. In addition, incentives should be provided through tax benefits for eco-labelled products to encourage consumers to purchase such products.

In case of end-of-life stage policies, while there are policies existing to tackle all types of waste ranging from hazardous waste to Municipal Solid Waste (MSW), Construction and Demolition (C&D) waste, plastic waste and e-waste, enforcement has been limited due to lack of support for business models that lead to better implementation. There is a need to mobilize funding or cost of treatment for waste through Extended Producer Responsibility (EPR) and Polluter Pays Principle. Also, there is a need for a unifying framework that brings together these different sources of secondary raw materials for effective closed-loop recycling. To effectively manage the dispersed waste steams there is also a need to involve the informal sector by providing them with technical capacity building and financial support.

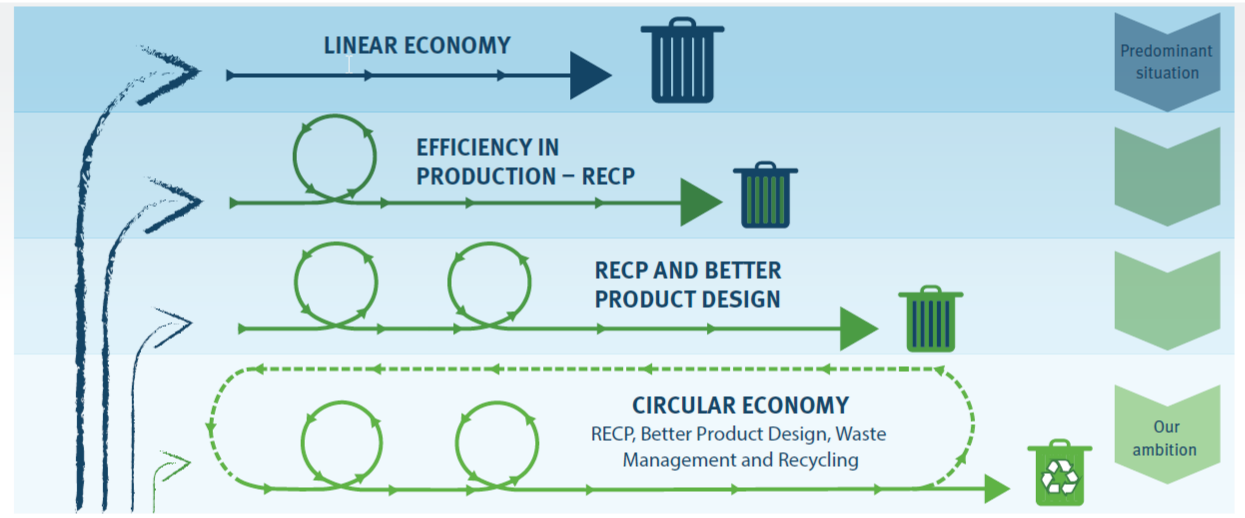


Fig3.9 Resource Efficiency Roadmap

Benefits of Resource Efficiency

Resource efficiency is a strategy to achieve the maximum possible benefit with least possible resource input. Fostering resource efficiency aims at governing and intensifying resource utilisation in a purposeful and effective way. Such judicious resource use brings about multiple benefits along the three dimensions of sustainable development - economic, social and environmental. Sustainable Development, by its very definition, must also take into consideration three critical aspects related to resource equity and access. Firstly, that all human beings, regardless of their location in the global socio-economic-environmental matrix, must have access to a minimum level of income and environmental quality for a dignified sustenance. Secondly, it also must ensure that the benefits, burdens and risks of resource use and conservation be equitably distributed. Thirdly, resource efficient production and consumption practices must take into account the needs of future generations by conserving access to resources.

Economic Benefits: RE has the potential to improve resource availability that is critical to the growth of industries, which translates into reduced price spikes due to supply constraints or disruptions. By using resources more efficiently, or by utilizing secondary resources, industries can improve competitiveness and profitability, since material cost is typically the largest cost for the manufacturing sector. RE-based innovations can also give industries an edge in the export market, as the experience of global leaders suchasGermany and Japan has shown. New industries can be created including those in the recycling sector, as well as in innovative design and manufacturing, and India can aspire to become a key innovation hub for RE (like it has for ITES). Finally, reduced import dependence for critical minerals helps to improve the country's trade balance and promote economic stability.

Social Benefits: Reduced extraction pressures due to adoption of RE strategies will help to reduce ecological degradation and pollution associated with mining. Reduced pressures from mining will provide further opportunities for undertaking landscape restoration and regeneration of degraded mined areas. Reduced waste generation will not only reduce pollution associated with disposal but also save related costs. Finally, resource extraction and use is highly energy intensive; and since our energy system is dominated by fossil fuels, it contributes to significant GHG emissions. Indeed, it is unlikely that global climate change mitigation goals can be met without a strong commitment to Resource Efficiency.

Environmental Benefits: Reduced extraction pressures due to adoption of RE strategies will help to reduce ecological degradation and pollution associated with mining. Reduced pressures from mining will provide further opportunities for undertaking landscape restoration and regeneration of degraded mined areas. Reduced waste generation will not only reduce pollution associated with disposal but also save related costs. Finally, resource extraction and use is highly energy intensive; and since our energy system is dominated by fossil fuels, it contributes to significant GHG emissions. Indeed, it is unlikely that global climate change mitigation goals can be met without a strong commitment to Resource Efficiency.

Resource Efficiency and SDGs

Resource Efficiency strategy provide multidimensional benefits for sustainable development, judicious use of resources is an important part of several SDGs, most obviously Goal 12 (responsible consumption and production) and Goal 8 (decent work and economic growth), but also those related to sustainable cities and communities (Goal 11), industry, innovation and infrastructure (Goal 9), climate action (Goal 13) and affordable & clean energy (Goal 7). Resource Efficiency strategy has the potential to make a substantial contribution to India's Nationally Determined Contributions (NDC) commitments under the 2015 Paris Climate Change Agreement. Further, it is important to recognize the implications of and potential for overlap of a Resource Efficiency strategy with several key policy priorities of the Government of India. With the government's goal of promoting India as a global manufacturing hub through its Make in India campaign and Zero Defect –Zero Effect scheme, the issue of using resources more efficiently and strategic planning for critical resources becomes extremely pertinent. The Smart Cities program envisages efficient urban infrastructure and the Housing for All mission has ambitious goals for affordable housing; both need judicious planning for resources to fulfil their aims. Waste and pollution reduction through adoption of RE approach can also contribute positively to the Swachh Bharat (Clean India) and Ganga Rejuvenation missions. Therefore, the rationale is overwhelming for India to adopt a comprehensive RE strategy as central to its developmental goals.

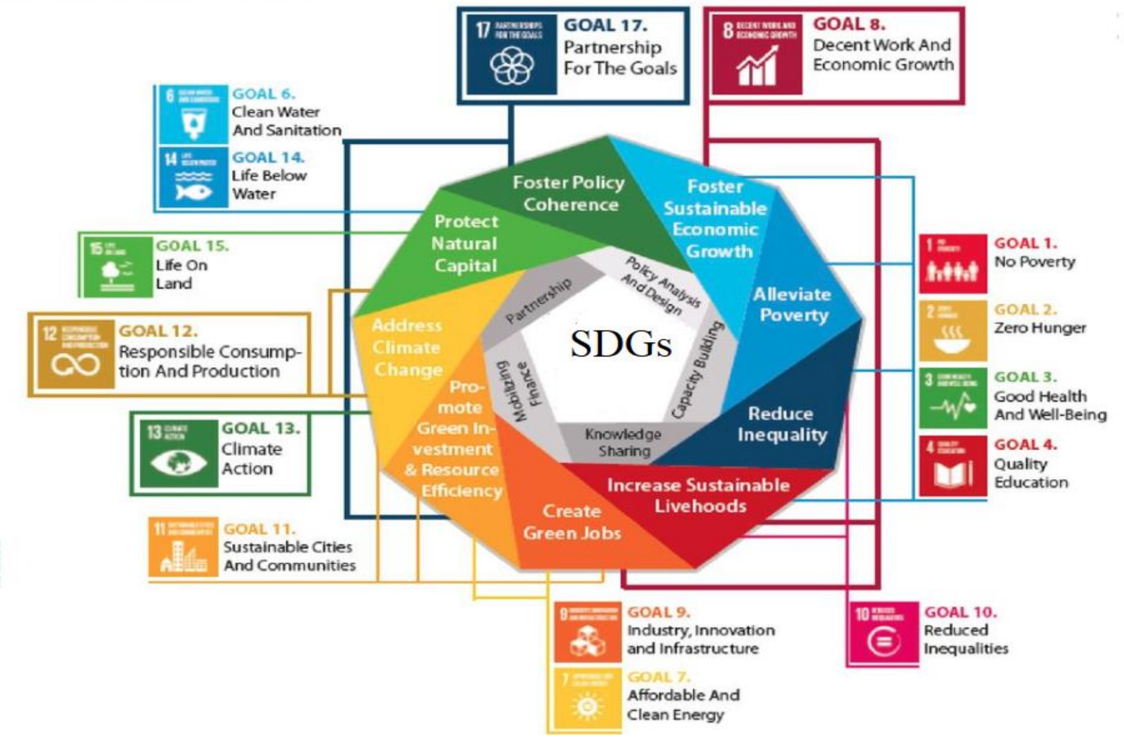


Fig 3.10 SDGs and Resource Efficiency

3.4 Behavioural Changes for Sustainable Consumption

Sustainability is the most pressing political problem of the 21st century, a consequence of climate change, environmental degradation and depletion, and exacerbated by a predicted massive expansion of the world's population. Patterns of personal and household consumption are also major sources of pressure. The preferred response of incumbent political elites is economic growth and technological innovation; ie business as usual with salvation achieved through 'cleaner' or 'greener' technologies whose development will return acceptable of profit to capitalist corporations. [lxxvi]Consumption, although often considered an individual choice, is deeply ingrained in behaviors, cultures, and institutions, and is driven and supported by corporate and government practices. Consumption is also at the heart of many of our most critical ecological, health, and social problems. What is referred to broadly as sustainable consumption has primarily focused on making consumption more efficient and gradually decoupling it from energy and resource use. We argue for the need to focus sustainable consumption initiatives on the key impact areas of consumption—transport, housing, energy use, and food—and at deeper levels of system change. To meet the scale of the sustainability challenges we face, interventions and policies must move from relative decoupling via technological improvements, to strategies to change the behavior of individual consumers, to broader initiatives to change systems of production and consumption. We seek to connect these emerging literatures on behavior change, structural interventions, and sustainability transitions to arrive at integrated frameworks for learning, iteration, and scaling of sustainability innovations. We sketch the outlines of research and practice that offer potentials for system changes for truly sustainable consumption.

Limitations of Individual Behavior Change

Most individuals in the developed world currently consume beyond sustainable levels. Even individuals who conceive of themselves as environmentalists and conscious consumers still make unsustainable choices. This disconnect can be attributed in part to the tendency of some behavioral interventions to be in direct competition with billions of dollars in marketing from corporations, rapid product obsolescence, easy credit systems that encourage debt-driven spending, transportation infrastructures that incentivize single-occupancy vehicle transit, work dynamics that encourage consumption, and prices that make it more affordable to purchase less sustainable options. Governments further spur consumption spending through tax policies, price controls for food, transport and consumer durables, trade agreements, monetary policy, as well as subsidies for resource extraction and manufacturing. Moreover, consumerism is the dominant economic and cultural paradigm of the 21st century. Greater division of labor and longer work hours incentivize consumption instead of nonmarket, household, or do-it-yourself activity. Work-life culture is increasingly a work-consume culture. Technological innovations are increasingly geared toward facilitating consumption nearly anywhere, anytime. Abstract notions of success and progress are defined economically, and the media cite GDP and stock market indices as measures of daily progress and stability. As Assadourian argues, this deep culture of consumption "stems from decades of engineering of a set of cultural norms, values, traditions, symbols, and stories that make it feel natural to consume ever larger amounts—of food, of energy, of stuff ... and over time 'consumers' deeply internalized this new way of living." Due to the multiplicity of influences on consumption, a narrow approach to change consumer behavior appears to be a weak lever.

Integrating Behavioral and Structural Change

If we take an integrated understanding that actors and their behaviors are conditioned by one another and also by the structures they inhabit, we are compelled to develop more comprehensive solutions that embed multiple behavioral interventions within broader structural reforms.

Interesting research has begun to emerge in this area of behavioral-structural integration, and provides useful insights into novel social and market developments, such as the collaborative and circular economies. In particular, research has shown that structures—markets, institutions, and policies—impart norms and values, and thus more than providing pathways of action, can generate feedback loops of learning. Indeed, collaborative economy researchers have focused a fair amount on the values of the movement. Research has hinted that individuals who participate in novel economic arrangements are likely to become politically engaged when their mode of living conflicts with traditional powers. Moreover, certain ecologically minded consumers are beginning to position their actions as part of collective processes, asserting that truly sustainable lifestyles necessitate political and collective decisions.

Behavior Change of Structural Actors

Effective sustainable consumption—that addresses environmental, social, and equity issues—likely requires addressing unsustainable infrastructures and institutions of consumption. Thus, we need to understand why certain infrastructural and institutional decisions are made and attempt to influence those decision processes. One path that has been studied seeks to apply behavioral insights to changing corporate and government practices around consumption, with the goal of motivating sustainable products, services, institutions, and infrastructures.

Changing Culture

System changes for sustainable consumption will likely co-evolve with culture changes. Assadourian (116, p. 113) argues that our "norms, stories, rituals, values, symbols, and traditions" influence nearly all of our life choices, in part by being codified in our public and private institutions. Thus, culture change can be seen as a by-product of and influence on changes in actors.

[lxxvii]Many researchers have come to the conclusion that an integrated vision is critical for the success of a post-consumerist society. This vision, with a reconstruction of understandings of wealth, affluence, and the "good life," needs to be codified in dominant societal institutions "to normalize an alternative set of practices, values, beliefs, stories, and symbols", and to serve as a guide for new lifestyles and infrastructures. Indeed, current practitioners—individuals, businesses, NGOs, and governments—need the support of a unified community collectively addressing broader principles. Some research has pointed to the ability of influential leaders or of institutional codification as effective methods of disseminating alternative narratives. However, research is still needed on methods to effectively spread alternative narratives to actors locked into consumption paradigms.

For guidance, we might look to certain niche contexts, where the codification of alternative narratives has been effective. The inclusion of "BuenVivir" or "good living" principles into the national constitutions in Ecuador and Bolivia has given a novel cultural framework that redefines affluence and creates a legal basis for sustainable development. Similarly, the development of the GNH (Gross National Happiness) Index in Bhutan has been surprisingly influential as a guide to an alternative development paradigm. Although western countries may be far from creating rights for nature, the French, British, German, Canadian, and Chinese governments have all followed Bhutan's lead and begun to incorporate measures of well-being into their national assessments. These codifications can signal to businesses, individuals, and communities that sustainability implications should be part of standard decision processes.

Given current trajectories of population and consumption growth, it is clear we face impending sustainability crises. Advances in industrial ecology, life-cycle assessment, and environmental sciences have helped to identify our greatest impact areas: energy, transportation, housing, and food systems. However, current efforts that focus on efficiency and market-based solutions are insufficient to solve even our climate change challenges, let alone account for intergenerational sustainability and equity. Truly sustainable consumption entails moving from efficiency improvements to lifestyle changes, to broader culture changes, to socio-technological system changes. Proposals for Factor 100 decoupling, 100% renewable power for transport and housing, and rapid decreases in the use of private automobiles, meat consumption, etc., will likely require a move to more equitable forms of consumption, post-consumerist institutions, structures, and cultures, and post-growth economics. The pathway to these transformations requires new frameworks, tools, and interventions for transitioning to and then sustaining future systems. Diverse fields of research—from social psychology to ecological economics to sustainability transitions—now point toward new theories, policies, and innovations for transforming consumption and production. These literatures and practices need to be further developed, and then integrated, tested, and implemented. Deep system change is likely only possible if we view interventions and actions through an integrated lens of behavioral, structural, institutional, and cultural change, and then situate these changes within a systems framework for learning, iteration, and scaling.

Sustainable consumption, we will need to develop and test a coherent package of integrated, adaptive, and reinforcing policies that address individual cognitive biases as well as deep infrastructural systems, and that support a scalable transition toward real prosperity, equity, and environmental sustainability.

3.5 Promoting Plastic Free Living

Plastic is a necessary evil. You can hardly do away with it. The amount of plastic that is disposed off every year can circle the earth four times. Every day we come across plastic in various forms such as garbage and grocery bags, bottles, food containers, computer keyboards, plastic mouse, coffee cup lids and other such products. Though plastic products are very convenient to use, they play a harmful role in polluting the environment.[lxxviii] Till the year 2000, the amount of plastic that was manufactured was far less as compared to that made in the first decade of this century. But where is all the plastic going? It would be startling to note that billions of tons of plastic is ending up in the world's oceans. Discarded plastic products can be found even in extreme polar latitudes.

The benefits of plastic are undeniable. The material is cheap, lightweight and easy to make. These qualities have led to a boom in the production of plastic over the past century. This trend will continue as global plastic production skyrockets over the next 10 to 15 years. We are already unable to cope with the amount of plastic waste we generate, unless we rethink the way we manufacture, use and manage plastics. Ultimately, tackling one of the biggest environmental scourges of our time will require governments to regulate, businesses to innovate and individuals to act.

The economic damage caused by plastic waste is vast. Plastic litter in the Asia-Pacific region alone costs its tourism, fishing and shipping industries $1.3 billion per year. In Europe, cleaning plastic waste from coasts and beaches costs about €630 million per year. Studies suggest that the total economic damage to the world's marine ecosystem caused by plastic amounts to at least $13 billion every year. The economic, health and environmental reasons to act are clear.

Single-use Plastics

[lxxix]Often also referred to as disposable plastics, are commonly used for plastic packaging and include items intended to be used only once before they are thrown away or recycled. These include, among other items, grocery bags, food packaging, bottles, straws, containers, cups and cutlery. The main polymers used to manufacture single-use plastic items and indicates their most common applications. Single-use plastic bags are used to carry goods and usually provided to customers at the point of sale. The most common shopping bags are made of a type of plastic called polyethylene – or polythene – a tough, light, flexible, synthetic resin obtained by polymerizing ethylene.

Single-use plastic bags and Styrofoam products are widely used because they are strong, cheap and hygienic ways to transport goods. Plastic groceries bags consume less energy and water to produce and generate less solid waste than paper bags, taking up less space in landfills. However, some of the characteristics that make them commercially successful – price, durability and resistance - also contribute to making them environmentally unsound (when mismanaged) and difficult to recycle.

Fig 3.11 Single Use Plastic

Environmental, Health-Social and Economic impacts of Single Use Plastic

Environmental:[lxxx]Plastics in the environment pose significant hazards to wildlife both on land and in the ocean. High concentrations of plastic materials, particularly plastic bags, have been found blocking the breathing passages and stomachs of hundreds of different species. Plastic bags in the ocean resemble jellyfish and are often ingested by turtles and dolphins who mistake them for food. There is emerging evidence that the toxic chemicals added during the manufacturing process transfer from the ingested plastic into the animals' tissues, eventually entering the food chain for humans as well. When plastic breaks down into microplastic particles, it becomes even more difficult to detect and remove from the open oceans. Therefore, the most effective mitigation strategy is to reduce their input.

Plastic bags can choke waterways and exacerbate natural disasters. In 1988, poor drainage resulting from plastic bag litter clogging drains contributed to devastating floods in Bangladesh, causing several deaths as two-thirds of the country was submerged.

Health-Social:[lxxxi]Styrofoam items contain toxic chemicals such as styrene and benzene. Both are considered carcinogenic and can lead to additional health complications, including adverse effects on the nervous, respiratory and reproductive systems, and possibly on the kidneys and liver. Several studies have shown that the toxins in Styrofoam containers can transfer to food and drinks, and this risk seems to be accentuated when people reheat the food while still in the container. In low-income regions, domestic waste - including plastics - is often burnt for heating and/or cooking purposes, exposing largely women and children to prolonged toxic emissions. Illegal disposal practices of plastics often take the form of open burning, accentuating the release of toxic gases that include furans and dioxins. Research has shown that in developed as well as in developing countries, littering of plastic bags and Styrofoam containers can lead to perceived 'welfare losses' associated for instance to the visual disamenity of a park being contaminated with litter. This increases the indirect social costs of plastic pollution. In developing countries with inadequate solid waste management regulations, plastic bag litter can aggravate pandemics. By blocking sewage systems and providing breeding grounds for mosquitoes and other pests, plastic bags can raise the risk of transmission of vector-borne diseases such as malaria. Plastic waste and microplastics, if ingested by fish or other marine life, can enter our food chain. Microplastics have already been found in common table salt and in both tap and bottled water. Although in recent years research on the effects of microplastics has been growing, still little is known about the exact impacts on human health.

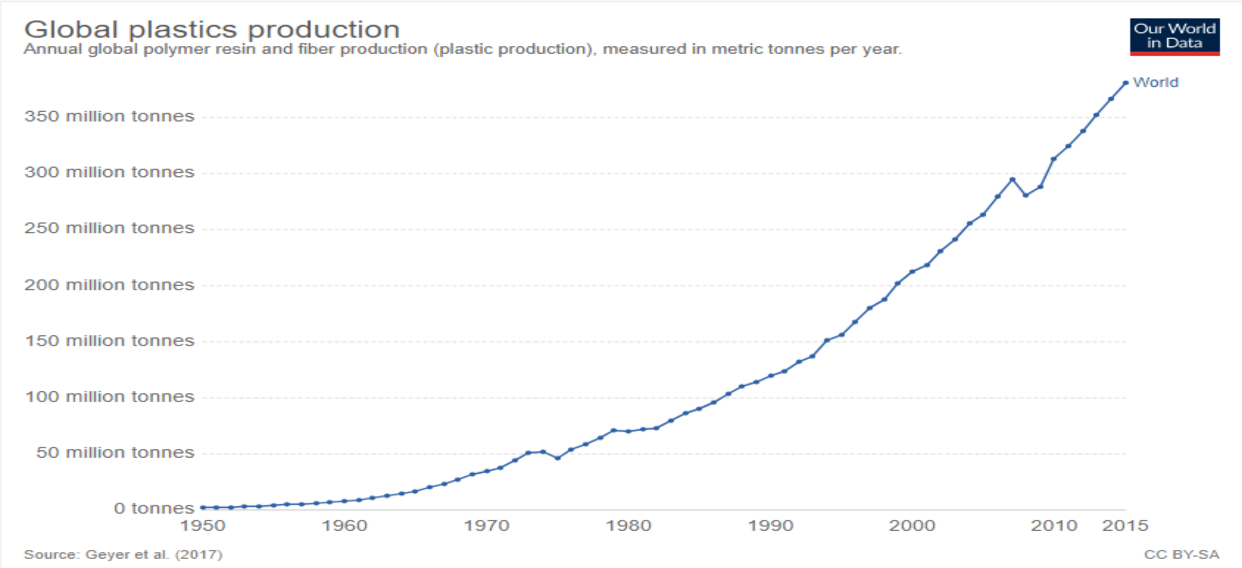


Fig 3. 12 Global plastics production

Economic: Stranded single-use plastics create visual pollution and are increasingly becoming a priority especially in countries that rely heavily on tourism as a major source of GDP, such as Small Island Developing States. For instance, Asia-Pacific Economic Cooperation (APEC) estimated a $1.3 billion42 economic impact of marine plastics to the tourism, fishing and shipping industries in that region alone.43 Styrofoam products present challenging recovery dynamics, making recycling – although technically possible – often financially unviable. For instance, Styrofoam usually can't be recycled locally but must instead be transported to a centralized plant. In addition, 95% of Styrofoam is air, making it not cost-effective to store or ship for recycling purposes. Foamed plastic products, cleaning such products, which are often contaminated with food or drinks, is difficult and energy-intensive, further increasing the cost of recycling.

Strategies to Promote Plastic-free Communities

The approach to become a Plastic Free Towns, Cities, and Nation is based on a step-by-step community framework, uniting individuals, schools, businesses, community groups, and local governments to drive action on reducing use of single-use plastics. The global commitments against single-use plastics underline a general sentiment to act against plastic pollution. The following sections map a different set of actions taken by the public, private sector entities and governments aimed at minimizing the production and use of plastic bags and Styrofoam items.

Waste management system improvements: Bans on plastic bags and Styrofoam items can effectively counter some of the symptoms of plastic overuse. However, better waste management systems, along with circular thinking, can help achieve long-term impacts and better address the problem of plastics in the environment. India will eliminate all single-use plastic in the country by 2022, the prime minister, NarendraModi, has announced.

The pledge is the most ambitious yet of the global actions to combat plastic pollution that are taking place in 60 nations around the world. Modi's move aims to drastically stem the flow of plastic from the 1.3 billion people living in the fastest growing economy in the world. "The choices that we make today will define our collective future," said Modi on Tuesday. "The choices may not be easy. But through awareness, technology, and a genuine global partnership, I am sure we can make the right choices. Let us all join together to beat plastic pollution and make this planet a better place to live."

Promotion of eco-friendly alternatives: [lxxxii]By working together with industry, governments can support the development and promotion of sustainable alternatives in order to phase out single-use plastics progressively. By introducing economic incentives, supporting projects which upscale or recycle single-use items and stimulating the creation of micro-enterprises, governments can contribute to the uptake of eco-friendly alternatives to single-use plastics.

In an effort to reduce plastic pollution, many governments have outlawed conventional plastic bags, allowing only the use and production of "biodegradable" bags. Nonetheless, to limit leakage and damage to the environment, the presence of sound waste management systems are as relevant for the so called bio-degradable options as for fossil fuel-based plastics. Often "biodegradable" plastic items (including single-use plastic bags and containers) break down completely only if exposed to prolonged high temperatures above 50°C (122°F). Such conditions are met in incineration plants, but very rarely in the environment. Therefore, even bioplastics derived from renewable sources (such as corn starch, cassava roots, or sugarcane33) or from bacterial fermentation of sugar or lipids (PHA34) do not automatically degrade in the environment and especially not in the ocean.

Social awareness and public pressure: Social awareness and education are essential to shape and encourage changes in consumer behaviour, but a gradual, transformational process is necessary. A longstanding change in cultural attitudes towards environmental matters is often not attainable through brief or stand-alone awareness campaigns. It is instead best achieved through embedding messaging in regular didactic practices and school curriculums from a very young age. Public awareness strategies can include a wide range of activities designed to persuade and educate. These strategies may focus not only on the reuse and recycling of resources, but also on encouraging responsible use and minimization of waste generation and litter.

Public pressure can act as a trigger for policy decision-making. In Bali for instance, the "Bye Bye Plastic Bags'' initiative is a social campaign lead by youth to mobilize people in Bali to say no to plastic bags. Two teenagers campaigned for over four years to get plastic bags banned from the island, starting with a petition that collected over 100,000 signatures. Despite initial resistance from the local government, the governor eventually signed a memorandum of understanding to phase out plastic bags by 2018.

Policy tools		Features
Regulatory instruments	Ban	Prohibition of a particular **Type** or combination of single-use plastics (including plastic bags, foamed plastic products, etc.). The ban can be total or partial (for those of certain specifications, e.g. plastic bags <30µ thickness).
Economic instruments	Levy on suppliers	Levy paid by suppliers of plastic bags (domestic producers or importers). For such a tax to be effective in inducing behavioural change, it should be fully passed on from suppliers to retailers, enticing the latter to (i) charge consumers for plastic bags or (ii) offer a rebate/reward to consumers who do not ask for plastic bags, promoting the use of reusable ones.
	Levy on retailers	Levy to be paid by the retailer when purchasing plastic bags. The retailers are not obligated to convey the tax to the consumers.
	Levy on consumers	Charge on each bag sold at the point of sale; standard price defined by law.
Combination of regulatory and economic instruments	Ban and levy	Combination of ban and levy (for instance a ban on thin plastic bags and a levy on thicker ones)

Fig 3.13 Policy tools to limit the use of plastic bags

Plastic pollution is an issue that connects the environment with all parts of society, and is something that we can take action on at every level. Indeed, it will only be through concrete, collective, positive action that we will be able to catalyse the shift that is needed to stop the flood of plastic pollution from overwhelming our world.

Increase demand for recycled materials

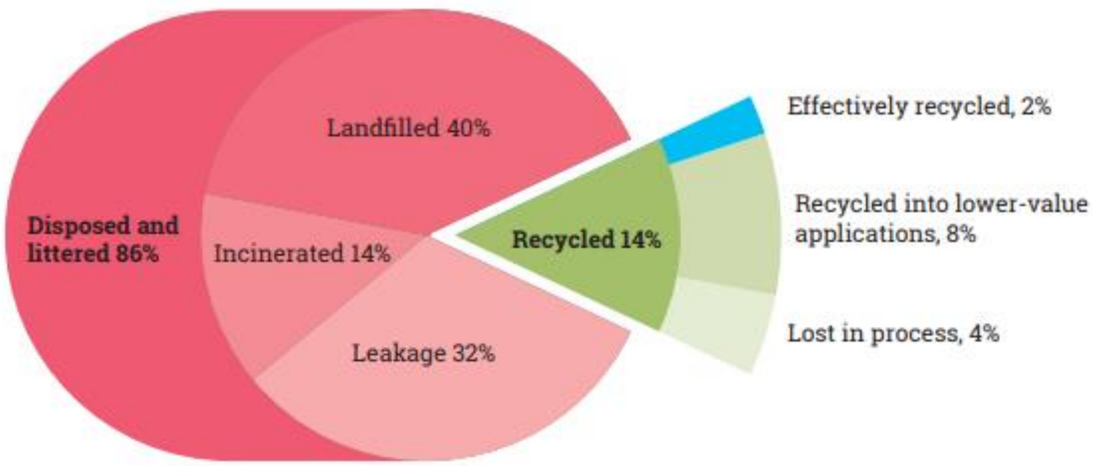


Fig3.14 Global flow of plastic packaging waste, 2015

Recycled plastic is being found in more and more products by request of both consumers and manufacturers. Recycling plastic is a service many cities see as beneficial enough to offer as a part of a standard waste management package. Consumers see reminders to recycle plastic packaging on labels and bins often strategically placed next to purchase areas. A newer label now becoming common is the amount of post-consumer waste in a product or packaging. Now not only recycling the item is important, but also making the item, or at least part of it, out of recycled materials adds value to consumer and manufacturer. Recycling plastic is common in many applications. Rotational molding has many opportunities to recycle products. Scrap materials are collected, cleaned, ground into plastic products, and made a uniform color. It can then be processed to make a variety of parts ranging from secondary containment products, laundry carts, bulk storage containers and more.

A growing number of rotomolded products are being manufactured out of recycled materials. However, food or medical grade applications must be manufactured in certified virgin prime materials with the use of recycled material.

Recycled Plastics Market Share

Production statistics for recycled plastics are largely unknown. However, data provided in Geyer, Jambeck and Law allow some rough approximations to be made. A global plastics recycling rate of 18%, and plastics waste generation of 258 Mtpa (both resins only) translate into approximately 46 million tonnes of recycled plastics production per year. This represents 12% of total global plastics production, but is likely to be an upper estimate because, in some cases, the material that is reported as "recycled" may refer only to the material diverted towards recycling: some proportion of this is likely to become recycling residues that require disposal.

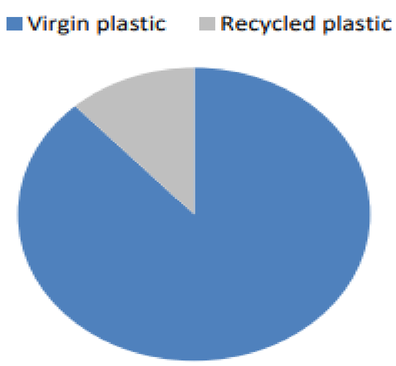


Fig 3.15 Estimated global market share of virgin and recycled plastics

Strategies to Increase Demand for Recycled Products

[lxxxiii]Manufacturers of recycled plastics operate in the same market as traditional (virgin) plastics producers, and are price takers in that market. At present, recycled plastic production is, for the most part, not economically competitive. Certain polymers (e.g., PET and HDPE), when used in in particular product categories (e.g., plastic bottles) are widely recycled, but this remains the exception rather than the rule. This is partly a consequence of the cost structure of recycled production, but also reflects virgin plastics prices that are highly volatile and perhaps too low to reflect all external costs. Unaddressed market failures and existing policy misalignments (e.g. government support for hydrocarbon inputs to plastics production) both contribute to the low prices for virgin plastics.

Supporting the Market for Recycled Plastics: Governments could address these challenges through policy interventions that aim to level the playing field between virgin and recycled plastics or support the market for recycled plastics. They include

- Taxes on the use of virgin plastics or differentiated value added taxes for recycled plastics or plastic products;
- Reform of support for fossil fuel production and consumption;
- Introduction of recycled content standards, targeted public procurement requirements, or recycled content labelling; and
- Creation of consumer education and awareness campaigns (concerning the environmental benefits of recycled plastics) in order to stimulate demand for products containing recycled plastics.

[lxxxiv]Manufacturing firms have incentives to use recycled plastics in their production processes. Doing so can create reputational benefits, and may also allow a small price premium to be charged if the final product can be marketed as “green”. That said, many manufacturers continue to rely solely on virgin plastic inputs, both because of their lower cost, but also due to inertia and uncertainty about the properties of recycled plastics. While the quality, performance characteristics, and near-term availability of virgin plastics are largely assured, there may be uncertainty about the same characteristics of recycled plastics. Status quo biases also hinder switching, even in situations where recycled plastics are cost competitive and of comparable quality to their virgin equivalents.

[lxxxv]There are also increasing concerns over additives (e.g. colours, plasticizers, flame retardants) used in the manufacture of some virgin plastics that complicate recycling or pose risks to human or ecological health. For manufacturers of recycled plastics, uncertainty about the presence of these

additives in plastic waste can hinder recycling altogether (because the resulting output may be of low quality or pose significant health risks in certain food related applications such as food packaging and children's toys). The lack of information and transparency regarding the use of additives in some plastic waste streams (e.g. electronics and other durables) is thus a major barrier to increased recycling of those products.

Governments of G7 countries could address these challenges through the following policy interventions:

- Creation of certification standards for recycled plastics;
- Creation of requirements to collect and recycle all types of plastic products;
- Facilitation of better coordination and communication across the plastics value chain, including through the promotion of chemical information systems; and
- Restrictions on the use of hazardous additives in plastics manufacturing.

Reducing the cost of recycled plastic production: The cost structure of recycled plastics production is different from that of virgin production and is, at current oil prices, often higher. There are a number of reasons for this.

[lxxxvi]Plastics waste generation is geographically dispersed, and aggregating waste materials into economically viable quantities incurs considerable collection and transport costs. In many cases, this waste is comingled with food residues, paper, and other materials. The separation of the plastics fraction (and the individual polymers of plastic) into clean feedstock for reprocessing can be technically challenging and involves considerable capital or labour costs. In addition, a significant proportion of the plastics in the waste stream are built into more complex end-of-life products that, in many cases, are difficult and costly to disassemble.'

On top of these factors, the alternative waste management options to recycling – landfill or incineration – are relatively cheap in many countries. The per-tonne charge levied for waste disposal may not necessarily reflect the full social cost of these alternatives.

Governments could address these challenges through the following policy interventions

- Introduction of multiple stream collection systems allowing separated collection of recyclables;

- Creation of incentives for better product and plastics design (e.g. design for reuse and recycling), such as through better designed extended producer responsibility, product stewardship and deposit-refund systems;
- Support for R&D for improved plastics management systems and the sustainable design of plastics (more easily recyclable or more easily biodegradable for example), working in close partnership with industry;
- Introduction of more ambitious recycling rate targets and harmonisation of the methods used to calculate these rates; and
- Increased stringency of landfill and incineration fees to better reflect the full social cost of these activities.

Increased international co-operation is needed to boost innovation and support improved environmental standards in fast growing markets: Countries can also address the barriers that hinder markets for secondary plastics through various forms of international cooperation.

[lxxxvii]First, by showcasing the public policy developments and private sector initiatives taking place in their respective countries, the G7 could help to promote the spread of best practices elsewhere. As touched upon in the Charlevoix Ocean Plastics Charter, this type of knowledge exchange could be enabled through the establishment of an international platform dedicated to plastics management.

Countries can go beyond sharing of best practices by promoting increased international cooperation in the area of plastics management.

- Countries could use official development assistance to support the development of effective and environmentally sound waste collection, sorting, and recycling infrastructure, including incentives or requirements for plastics source separation. A lack of collection capacity in emerging market economies leads to a significant loss of potentially recyclable material each year and limits the scale of the market for recyclable plastics. Globally, about 2 billion people do not have access to basic waste collection services. This is a key driver of marine plastics pollution and deprives the recycled plastics industry of scale, and the cost efficiencies that potentially come with scale.
- Countries could promote stronger environmental standards in plastic sorting and recycling in emerging and developing countries. Convergence of environmental standards relating to material recovery would allow waste plastics to flow towards countries with a comparative cost advantage in sorting and recycling activities, thereby helping to boost global recycling

rates while also generating shared economic benefits and improved environmental outcomes.

- Countries can co-operate to boost innovation that supports product design for reuse and recycling. This would facilitate recycling, reduce contamination in the waste stream, reduce costs, and provide better quality recycled plastic, as laid out by G7 leaders at their recent meeting in Charlevoix. Coordinated efforts on the provision of public R&D support and incentives for the development of more efficient processing technologies could also help to lower the overall cost of material recovery activities and improve material quality.

Summary

1. 'Zero maintenance' has become the Unique Selling Proposition of products to fit into the changing lifestyles of urban societies. This has propelled the 'Use and Throw' culture.
2. Frequent changes in product design and user compatibility ecosystem creates demand for replacing the product in shorter product lifespans.
3. Changing technology in short periods reduces product lifespan, further making products obsolete. It increases constant demand for new generation of similar products with minor value addition.
4. Globalization has made easy accessibility of goods and services across geographical and political boundaries.
5. Packaging has become integral part of products, to ensure product safety, and marketability increasing package waste.
6. Growth in retail food, hospitality, and tourism sector has increased the use of disposables.
7. Increased use of disposable medical and sanitation products has increased spread of communicable diseases – raising need for responsible disposal mechanism.
8. Responsible waste management practices in medical waste.
9. Effective monitoring and evaluation of waste management and recycling processes.
10. Changes in consumer behavior requires larger systemic and policy changes. In addition to consumer sensitization towards responsibilities, for social and environmental concerns, by establishing and monitoring consumer behavioral indicators.

To do Activities

1. Identify and analyze social behavioral changes of identified community towards the use of Disposable Products and Single Use plastics in the last five years.
2. Conduct a study to identify viable strategies to enhance resource efficiency in rural production systems.

Chapter 4 - Building Sustainability

Introduction

Principles of sustainability offers strategies to optimize the stable operation between the inflow and outflow of materials and energy. This aptly fits in the area of waste management. Raw materials are becoming scarcer and energy more expensive, and all around the world, soil, and air and water pollution pose a risk to sustainable development. Waste management is closely associated with both these problems: waste disposal issues are exacerbated by changing patterns of consumption, industrial development and urbanisation; this in turn means that traditional systems for solid waste disposal and recycling are no longer appropriate. Many developing and emerging countries are faced with the major challenge of improving their inadequate and unsustainable waste management systems. This problem affects informal settlements in particular.

Conventionally, waste is isolated from the production cycle, as it is not recognized as integral to profitability - only to be managed when the pressure to handle the problem is greater than the convenience of disposal. The catalyst to manage the problem eventuates when the waste disposal impacts (polluted air, water or full landfills) affect people. Waste handling technologies have evolved, however the lack of scientific management approaches are falling short. Globally, efforts are being made to address the challenges through development of environment friendly beneficial products through materials and energy recovery.

Solid waste is accepted as a major challenge and should be handled by technically trained manpower, with management perspectives. There is a felt need in developing technical courses by competent academic and research institutes, further authorized by concerned authorities. The holistic waste management strategies ensures, issues concerned with environment, including human well-being

Entire gambit of this process call for active participation of all stakeholders. Sustainable waste management emphasizes innovative designs, approaches, environmentally acceptable technologies falling in-tune with geo-bio climatic conditions which include socio-cultural, and economic systems.

Objective: The objective of the unit is to sensitize the students on the untapped value of generated waste as secondary resource, with economic value. The aim is to build competence in emerging Practices and systems, scope & opportunities in waste management through case studies. Concepts of resource potential and recovery as a scope for business and paves a way for sustainable waste management strategies.

4.1 Principles of Sustainable Waste Management

Waste management is the precise name for the collection, transportation, disposal or recycling and monitoring of waste. This term is assigned to the material, waste material that is produced through human being activity. This material is managed to avoid its adverse effect over human health and environment. Most of the time, waste is managed to get resources from it. The waste to be managed includes all forms of matter i.e. gaseous, liquid, solid and radioactive matter.

The methods for the management of waste may differ for developed and developing nations. For urban and rural populations, industrial and residential areas it does differ as well. The management of waste in metropolitan and rural areas is general responsibility of the local government. While the waste that is produced by the industries is managed by the industry itself, incase it is non-hazardous.

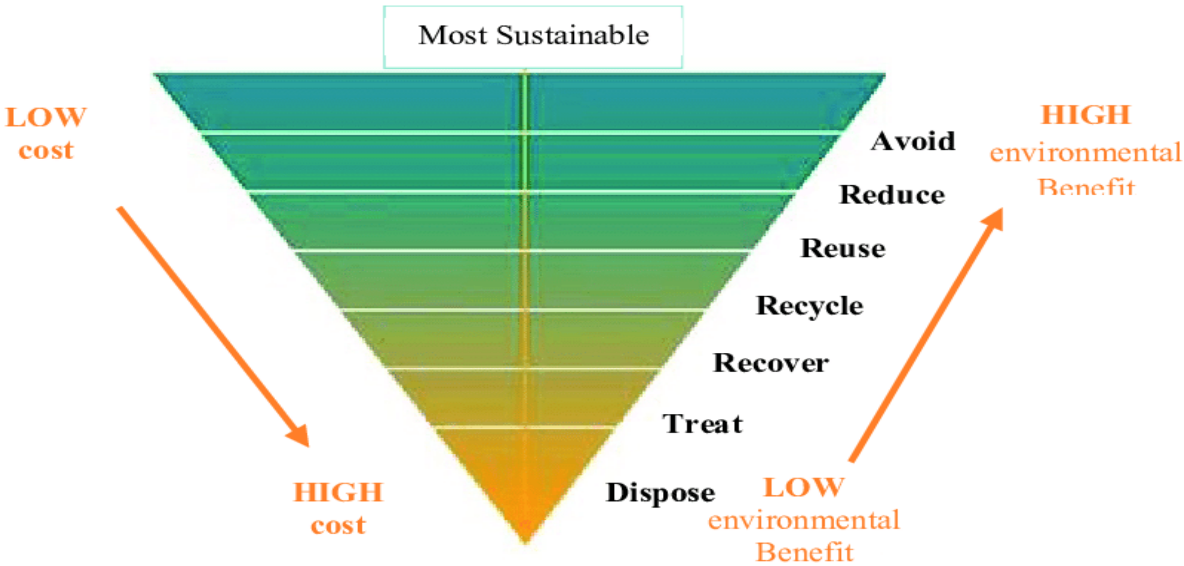


Fig 4.1 Waste Hierarchy

To mitigate the impact of this consumerism two parallel lines of action should be put forward. First, the dominant habits in consumer cultures has to be changed. Transforming cultural habits takes decades of effort to happen. A key to this change is to direct the fundamental cultural institutions such as education, business, government and media towards sustainability. Second, focusing on utilizing solid waste management drivers, frame works, performance indicators that could catalyze the transfer to a more sustainable system.

The development of a sustainable waste management system, particularly for rapidly growing cities in developing economies, entails designing a sustainable system which must quickly become effective while generating a revenue that could guarantee its sustainability. The main objectives of the system is drastically reducing open dumping and uncontrolled burning practices. Educating citizens to abandon these practices, which have damaging impacts both on their environment and their health, in developing economies is certainly fundamental. Designing a system which is capable of providing incentives to deviate from these harmful practices is a strategy that is likely to guarantee sustainability.

Waste management rules in India are based on the principles of "sustainable development", "precaution" and "polluter pays". These principles mandate municipalities and commercial establishments to act in an environmentally accountable and responsible manner—restoring balance, if their actions disrupt it. The increase in waste generation as a by-product of growing consumption has led to various subordinate legislations for regulating the manner of disposal and dealing with generated waste are made under the umbrella law of Environment Protection Act, 1986 (EPA).

Waste Hierarchy

Waste hierarchy is a tool used in the evaluation of processes that protect the environment alongside resource and energy consumption to most favourable to least favourable actions. The hierarchy establishes preferred program priorities based on sustainability. To be sustainable, waste management cannot be solved only with technical end-of-pipe solutions and an integrated approach is necessary.

The waste management hierarchy indicates an order of preference for action to reduce and manage waste, and is usually presented diagrammatically in the form of a pyramid. The hierarchy captures the progression of a material or product through successive stages of waste management, and represents the latter part of the life-cycle for each product.

The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The proper application of the waste hierarchy can have several benefits. It can help prevent emissions of greenhouse gases, reduces pollutants, save energy, conserves resources, create jobs and stimulate the development of green technologies.

Sustainable Waste Management

Effective solid management systems are needed to ensure better human health and safety. They must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management must be both environmentally and economically sustainable.

- Environmentally sustainable: It must reduce, as much as possible, the environmental impacts of waste management.

- Economically sustainable: It must operate at a cost acceptable to community.

Clearly it is difficult to minimise the two variables, cost and environmental impact, simultaneously. There will always be a trade-off. The balance that needs to be struck is to reduce the overall environmental impacts of the waste management system as far as possible, within an acceptable level of cost. An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach i.e. it deals with all types of solid waste materials and all sources of solid waste. A multi-material, multi-source management approach is usually effective in environmental and economic terms than a material specific and source specific approach. Specific wastes should be dealt within such a system but in separate streams. An effective waste management system includes one or more of the following options

- Waste collection and transportation.
- Resource recovery through sorting and recycling i.e. recovery of materials (such as paper, glass, metals) etc. through separation.
- Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes.
- Waste transformation (without recovery of resources) i.e. reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal.
- Disposal on land i.e. environmentally safe and sustainable disposal in landfills

The activities associated with the management of municipal solid wastes from the point of generation to final disposal can be grouped into the six functional elements: (a) waste generation; (b) waste handling and sorting, storage, and processing at the source; (c) collection; (d) sorting, processing and transformation; (e) transfer and transport; and (f) disposal.

Waste Generation

Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal. Waste generation is, at present, an activity that is not very controllable. In the future, however, more control is likely to be exercised over the generation of wastes. Reduction of waste at source, although not controlled by solid waste managers, is now included in system evaluations as a method of limiting the quantity of waste generated.

Waste Handling, Sorting, Storage, and Processing at the Source

The second of the six functional elements in the solid waste management system is waste handling, sorting, storage, and processing at the source. Waste handling and sorting involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. For example, the best place to separate waste materials for reuse and recycling is at the source of generation. Households are becoming more aware of the importance of separating newspaper and cardboard, bottles/glass, kitchen wastes and ferrous and non-ferrous materials.

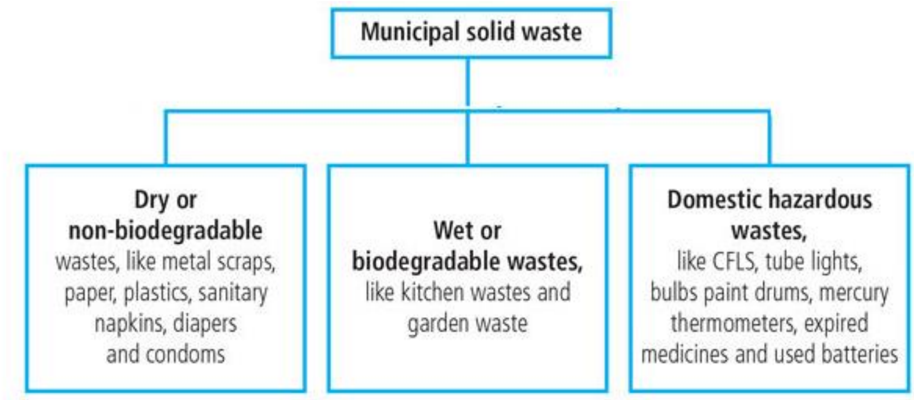


Fig 4.2 Waste Segregation

Onsite storage means the temporary collection of waste at the household level. It is important that waste is stored in proper containers. These could be baskets, preferably made from locally available materials, plastic buckets or metal containers. Larger containers or dustbins, especially those used for food waste, should be leakproof, have tight lids and be long-lasting. The size of the container should be sufficient to hold at least the amount of solid waste that is generated per day at household level. Institutions and businesses should consider having onsite storage facilities with greater capacity. The proper location of storage containers and the frequency and time of emptying are important factors to be considered for efficient onsite storage.

Collection

The functional element of collection, includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a materials processing facility, a transfer station, or a landfill disposal site.

Sorting, Processing and Transformation of Solid Waste

The sorting, processing and transformation of solid waste materials is the fourth of the functional elements. The recovery of sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. Sorting of commingled (mixed) wastes usually occurs at a materials recovery facility, transfer stations, combustion facilities, and disposal sites. Sorting often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals.

Waste processing is undertaken to recover conversion products and energy. The organic fraction of Municipal Solid Waste (MSW) can be transformed by a variety of biological and thermal processes. The most commonly used biological transformation process is aerobic composting. The most commonly used thermal transformation process is incineration.

Waste transformation is undertaken to reduce the volume, weight, size or toxicity of waste without resource recovery. Transformation may be done by a variety of mechanical (eg shredding), thermal (e.g. incineration without energy recovery) or chemical (e.g. encapsulation) techniques.

Transfer and Transport

The functional element of transfer and transport involves two steps: (i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

Disposal

The final functional element in the solid waste management system is disposal. Today the disposal of wastes by landfilling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from Materials Recovery Facilities (MRFs), residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes on land or within the earth's mantle without creating nuisance or 16 hazard to public health or safety, such as breeding of rodents and insects and contamination of groundwater.

4.2 Evolution of Waste Management Practices

The classical drivers of waste management practices have been health and safety issues, along with scarcity of resources, and handling them for the sake of splendor. Generally, in both Europe and America, the industrial revolution led to a series of events, driving governmental interest in public health. Therefore, more sophisticated waste management practices were adopted by means of legislations and infrastructure. Through the nineteenth century public health legislation continued ruling the waste management agenda, with collection and removal of waste from the residential area the major priority. Meanwhile, through the twentieth century, before 1970, unregulated and uncontrolled disposal was common, including dumping and burning. It was the environmental movement in the 1970s which caused a substantial shift in policymakers' perspectives on the SWM framework. Waste control, through managing landfills' and incinerators' safety and functionality was the main objective. Beginning from the 1980s and up until now, increasing technical standards have been in instruction. Landfill gas and leachate control, incinerator gas and dioxin reduction, and odor control for composting facilities and anaerobic digesters are some examples.

Historically through most of human history before the industrial revolution, due to the scarcity of resources, goods were repaired and reused rather than discarded. However, in the eighteenth and nineteenth century, extensive increase in consumption resulted in much less reuse and repair. Nevertheless, when the waste hierarchy was introduced in the 1970s, somewhat of a revival of concerns came about. The hierarchy of waste management options orders waste management options according to preference from highest to lowest: prevention of waste generation, waste minimization or source reduction followed by reuse, recycling, composting, waste to energy, incineration without energy recovery and landfilling. However, there are different versions of the hierarchy with varying priorities. A transition from end of pipe to preventative thinking took place, particularly after the introduction of the concept in the European Union's Second Environment Action Program in 1977. Terms like pollution prevention, source reduction, waste minimization, waste reduction, reduction in use of toxics, clean or cleaner technology, etc. were introduced thereafter and the perspective changed from reaction and control to prevention.

Another important environmental driver for waste management has been global warming concerns since the 1990s. Landfills can be a source of methane production. Therefore, a series of preventative policies, including targets for compost and recycling levels promoting diversion from landfills were set and the concept of extended producer responsibility was introduced. Although the possibility of carbon reduction is in conjunction with sound waste management, but the impacts will be noticeable only if many countries contribute. In other words, direct and immediate national advantages for reducing greenhouse gas emissions are not recognized and this might be a reason why carbon reduction is not a powerful driver for promoting waste management practices.

In a nutshell, since the 1960s and the change of the international agenda towards the environment, many developed countries have made great steps in managing waste, presenting many good practice examples. Meanwhile, the approach has changed from controlling and managing after being discarded, to preventing waste generation, minimizing and reusing, reducing hazardous substances in the design phase and keeping residues concentrated and separate, if not prevented, to preserve their intrinsic value for recycling and recovery and prevent them from contaminating other valued waste. The perception has changed from "waste" to "resource." Hence, terms like "waste and resource management" and "resource management" are gradually substituting "waste management". This is while low- and middle-income countries still face basic challenges, that is, waste collection services coverage, confronting uncontrolled disposal and burning. Moreover, the population is growing fast in these countries, making it even harder to manage.

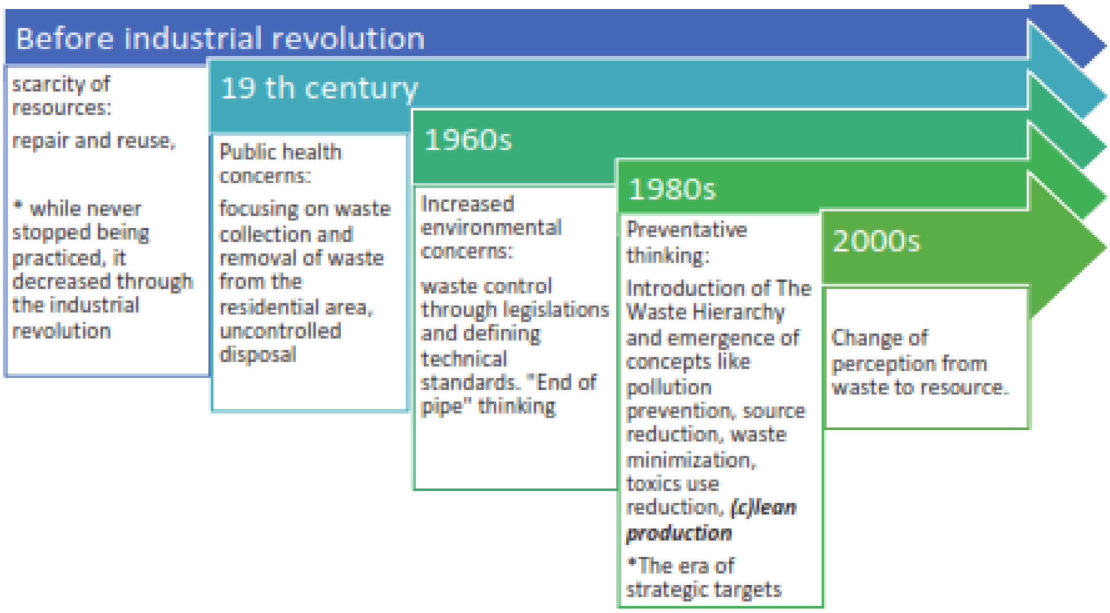


Fig 4.3 Evolution of Waste Management Practices

4.3 Extended Producer Responsibility (EPR)

In the field of waste management, extended producer responsibility (EPR) is a strategy to add all of the environmental costs associated with a product throughout the product life cycle to the market price of that product. Extended producer responsibility legislation is a driving force behind the adoption of remanufacturing initiatives because it "focuses on the end-of-use treatment of consumer products and has the primary aim to increase the amount and degree of product recovery and to minimize the environmental impact of waste materials".

The concept was first formally introduced in Sweden by Thomas Lindhqvist in a 1990 report to the Swedish Ministry of the Environment. In subsequent reports prepared for the Ministry, the following definition emerged: "[EPR] is an environmental protection strategy to reach an environmental objective of a decreased total environmental impact of a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal.

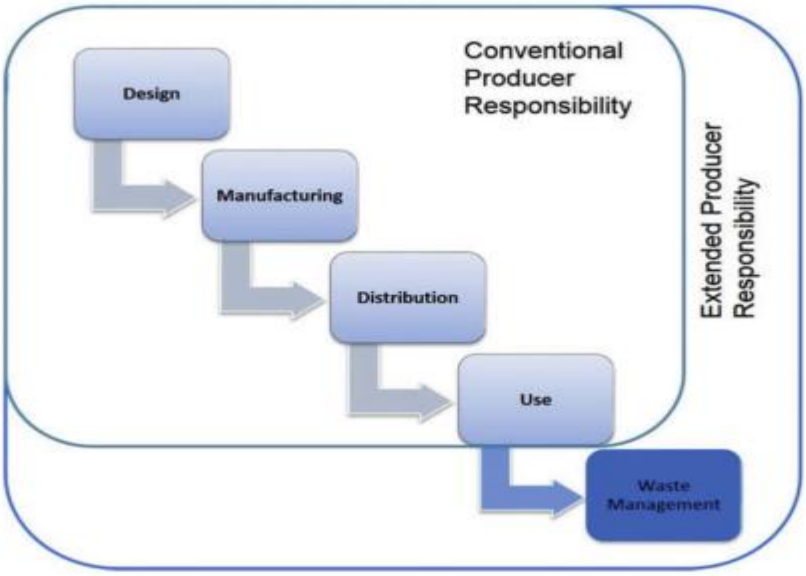


Fig 4.4 EPR

How the EPR model works

EPR uses [financial incentive] to encourage manufacturers to design environmentally friendly products by holding producers responsible for the costs of managing their products at end of life. This policy approach differs from product stewardship, which shares responsibility across the chain of custody of a product, in that it attempts to relieve local governments of the costs of managing certain priority products by requiring manufacturers to internalize the cost of recycling within the product price. EPR is based on the principle that manufacturers (usually brand owners) have the greatest control over product design and marketing and have the greatest ability and responsibility to reduce toxicity and waste.

EPR may take the form of a reuse, buyback, or recycling program. The producer may also choose to delegate this responsibility to a third party, a so-called producer responsibility organization (PRO), which is paid by the producer for used-product management. In this way, EPR shifts the responsibility for waste management from government to private industry, obliging producers, importers and/or sellers to internalize waste management costs in their product prices and ensure the safe handling of their products.

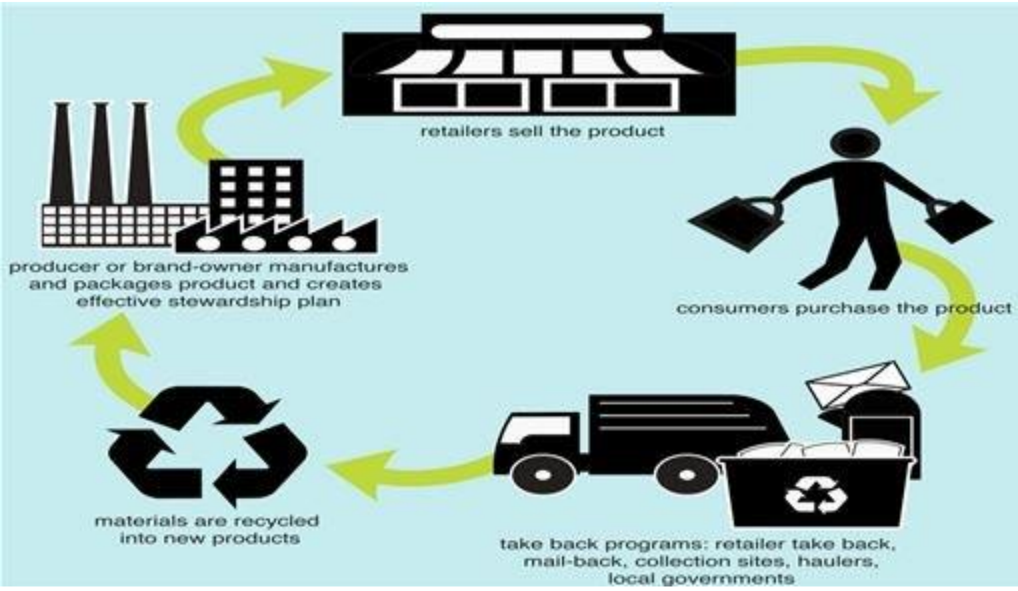


Fig 4.5 EPR Cycle

A good example of a producer responsibility organization is PRO Europe S.P.R.L. (Packaging Recovery Organisation Europe), founded in 1995, the umbrella organization for European packaging and packaging waste recovery and recycling schemes. Product stewardship organizations like PRO Europe are intended to relieve industrial companies and commercial enterprises of their individual obligation to take back used products through the operation of an organization which fulfills these obligations on a nationwide basis on behalf of their member companies. The aim is to ensure the recovery and recycling of packaging waste in the most economically efficient and ecologically sound manner. In many countries, this is done through the Green Dot trademark of which PRO Europe is the general licensor. In twenty-five nations, companies are now using the Green Dot as the financing symbol for the organization of recovery, sorting and recycling of sales packaging.

Take-back Policy

In response to the growing problem of excessive waste, several countries adopted waste management policies in which manufacturers are responsible for taking back their products from end users at the end of the products' useful life, or partially financing a collection and recycling infrastructure. These policies were adopted due to the lack of collection infrastructure for certain products that contain hazardous materials, or due to the high costs to local governments of providing such collection services. The primary goals of these take-back laws therefore are to partner with the private sector to ensure that all waste is managed in a way that protects public health and the environment. The goals of take-back laws are to

- Encourage companies to design products for reuse, recyclability, and materials reduction.
- Correct market signals to the consumer by incorporating waste management costs into product price.
- Promote innovation in recycling technology.

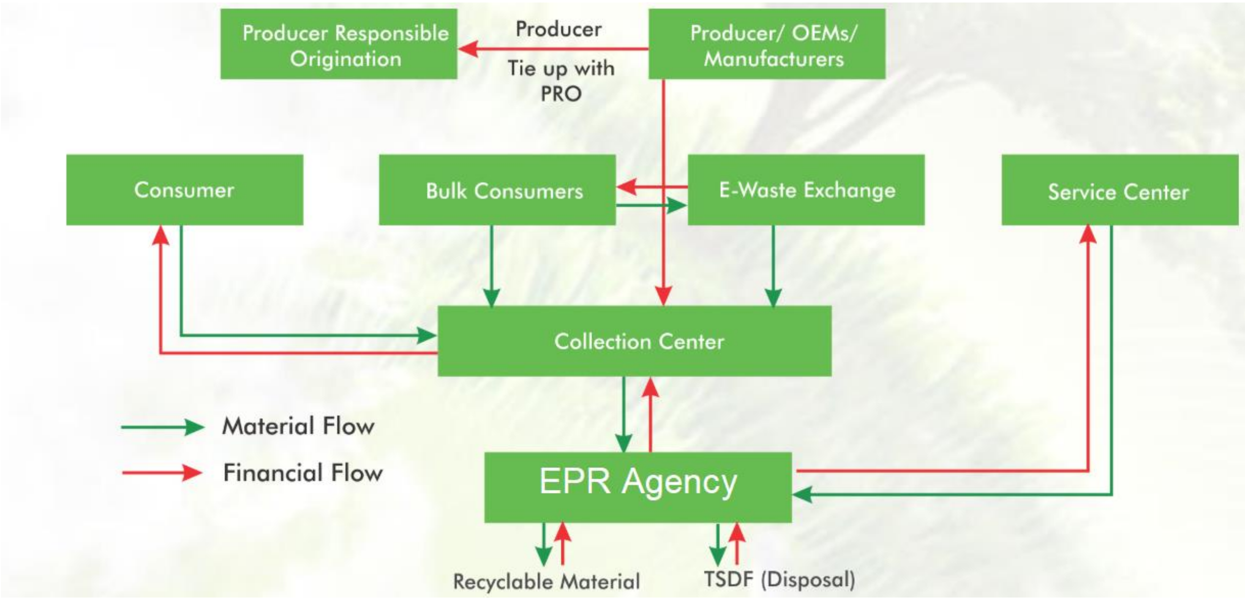


Fig 4.6 EPR Working Model

Take-back programs help promote these goals by creating incentives for companies to design products that minimize waste management costs, to design products that contain safer materials (so they do not need to be managed separately), or to design products that are easier to recycle and reuse (so recycling becomes more profitable).[10] The earliest take-back activity began in Europe, where government-sponsored take-back initiatives arose from concerns about scarce landfill space and potentially hazardous substances in component parts. The European Union adopted a directive on Waste Electrical and Electronic Equipment (WEEE). The purpose of this directive is to prevent the production of waste electronics and also to encourage reuse and recycling of such waste. The directive requires the Member States to encourage design and production methods that take into account the future dismantling and recovery of their products. These take-back programs have been adopted in nearly every OECD country. In the United States, most of these policies have been implemented at the state level.

Take-back e-Waste

Many governments and companies have adopted extended producer responsibility to help address the growing problem of e-waste — used electronics contain materials that cannot be safely thrown away with regular household trash. In 2007, according to the Environmental Protection Agency, people threw away 2.5 million tons of cell phones, TVs, computers, and printers. Many governments have partnered with corporations in creating the necessary collection and recycling infrastructure. Some argue that local and manufacturer-supported extended producer responsibility laws give manufacturers greater responsibility for the reuse, recycling, and disposal of their own products.

The kinds of chemicals found in e-waste that are particularly dangerous to human health and the environment are lead, mercury, brominated flame-retardants, and cadmium. Lead is found in the screens of phones, TVs and computer monitors and can damage kidneys, nerves, blood, bones, reproductive organs, and muscles. Mercury is found in flat screen TVs, laptop screens, and fluorescent bulbs, and can cause damage to the kidneys and the nervous system. Brominated flame-retardants found in cables and plastic cases can cause cancer, disruption of liver function, and nerve damage. Cadmium is found in rechargeable batteries and can cause kidney damage and cancer. Poorer countries are dumping grounds for e-waste as many governments accept money for disposing this waste on their lands. This causes increased health risks for people in these countries, especially ones who work or live close to these dumps.

In the United States, 25 states have implemented laws that require the recycling of electronic waste. Of those, 23 have incorporated some form of extended producer responsibility into their laws. According to analysis done by the Product Stewardship Institute, some states have not enacted EPR laws because of a lack of recycling infrastructure and funds for proper e-waste disposal. In contrast, according to a study of EPR legislation done by the Electronics TakeBack Coalition, states that have seen success in their e-waste recycling programs have done so because they have developed a convenient e-waste infrastructure or the state governments have instituted goals for manufacturers to meet.

Advocates for EPR also argue that including "high expectations for performance" into the laws, and ensuring that those are only minimum requirements, contribute to making the laws successful. The larger the scope of products that can be collected, the more e-waste will be disposed of properly.

Similar laws have been passed in other parts of the world as well. The European Union has taken steps to address some electronic waste management issues. They have restricted the use of harmful substances in member countries and have made it illegal to export waste.

The Chinese laws regarding e-waste are similar to the ones in the EU, but they focus on banning the import of e-waste. This has proven to be difficult, however, because illegal smuggling of waste still occurs in the country. In order to dispose of e-waste in China today, a license is required and plants are held responsible for treating pollution.

EPR Implementation

EPR has been implemented in many forms, which may be classified into three major approaches:

- Mandatory
- Negotiated
- Voluntary

It is perhaps because of the tendency of economic policy in market-driven economies not to interfere with consumers' preferences that the producer-centric representation is the dominant form of viewing the environmental impacts of industrial production: in statistics on energy, emissions, water, etc., impacts are almost always presented as attributes of industries ("on-site" or "direct" allocation) rather than as attributes of the supply chains of products for consumers. On a smaller scale, most existing schemes for corporate sustainability reporting include only impacts that arise out of operations controlled by the reporting company, and not supply-chain impacts. According to this world view, "upstream and downstream [environmental] impacts are ... allocated to their immediate producers. The institutional setting and the different actors' spheres of influence are not reflected".

On the other hand, a number of studies have highlighted that final consumption and affluence, especially in the industrialised world, are the main drivers for the level and growth of environmental pressure. Even though these studies provide a clear incentive for complementing producer-focused environmental policy with some consideration for consumption-related aspects, demand-side measures to environmental problems are rarely exploited.

The nexus created by the different views on impacts caused by industrial production is exemplified by several contributions to the discussion about producer or consumer responsibility for greenhouse gas emissions. Emissions data are reported to the IPCC as contributions of producing industries located in a particular country rather than as embodiments in products consumed by a particular population, irrespective of productive origin. However, especially for open economies, taking into account the greenhouse gases embodied in internationally traded commodities can have a considerable influence on national greenhouse gas balance sheets. Assuming consumer responsibility, exports have to be subtracted from, and imports added to national greenhouse gas inventories. In Denmark, for example, Munksgaard and Pedersen (2001) report that a significant amount of power and other energy-intensive commodities are traded across Danish borders, and that between 1966 and 1994 the Danish foreign trade balance in terms of CO2 developed from a 7Mt deficit to a 7Mt surplus, compared to total emissions of approximately 60 Mt. In particular, electricity traded between Norway, Sweden and Denmark is subject to large annual fluctuations due to varying rainfall in Norway and Sweden. In wet years Denmark imports hydro-electricity whereas electricity from coal-fired power plants is exported in dry years. The official Danish emissions inventory includes a correction for electricity trade and thus applies the consumer responsibility principle.

Similarly, at the company level, "when adopting the concept of eco-efficiency and the scope of an environmental management system stated in for example ISO 14001, it is insufficient to merely report on the carbon dioxide emissions limited to the judicial borders of the company". "Companies must recognise their wider responsibility and manage the entire life-cycle of their products ... Insisting on high environmental standards from suppliers and ensuring that raw materials are extracted or produced in an environmentally conscious way provides a start." A life-cycle perspective is also taken in EPR frameworks: "Producers of products should bear a significant degree of responsibility (physical and/or financial) not only for the environmental impacts of their products downstream from the treatment and disposal of their product, but also for their upstream activities inherent in the selection of materials and in the design of products. The major impetus for EPR came from northern European countries in the late 1980s and early 1990s, as they were facing severe landfill shortages. [... As a result,] EPR is generally applied to post-consumer wastes which place increasing physical and financial demands on municipal waste management.

EPR has rarely been consistently quantified. Moreover, applying conventional life cycle assessment, and assigning environmental impacts to producers and consumers can lead to double-counting. Using input-output analysis, researchers have attempted for decades to account for both producers and consumers in an economy in a consistent way. Researchers demonstrate and discuss a method of consistently delineating producers' supply chains, into mutually exclusive and collectively exhaustive responsibilities to be shared by all agents in an economy. Their method is an approach to allocating responsibility across agents in a fully inter-connected circular system. Upstream and downstream environmental impacts are shared between all agents of a supply chain – producers and consumers.

Ministry of Environment, Forests and Climate Change has recently published the e-Waste (Management) Rules 2016 for environmentally sound management of e-waste. According to this rule.

- Producers have to obtain 'Extended Producer Responsibility Authorization' from Central Pollution Control Board (CPCB).
- Manufacturers of Electrical and Electronic Equipment would also need Authorization from State Pollution Control Boards (SPCB).

4.4 Sustainable Materials Management

Sustainable materials management (SMM) is a term chosen by the OECD for representing a holistic approach towards sustainable resource consumption, taking into account all stages of a product's life cycle, aiming at minimum environmental impacts and preserving natural capital in consistence with maintaining economic efficiency and social equity. While the term is well defined and is agreed upon globally, it is one of many terms used in the context of sustainable development to address the sustainable use of natural resources. This chapter is aimed at presenting a picture of the history of waste and resource management practices, introducing different concepts and approaches towards sustainable material management and highlighting the evolutions of these issues.
There are various drivers that compel us to look beyond the traditional forms of material management, and aim for solutions that are sustainable. For example:

- Material use has accelerated globally since the 1970s. While population has almost doubled, global economy has expanded more than threefold and global material extraction has tripled as well. The global trend is towards growth in material use resulting from population and economic growth and increasing living standards. Some have proposed the simple – yet useful –calculation that human impact on natural resources is proportional to the population, affluence, and technology (Impact =Population +Affluence +Technology). If technology enables the more efficient use of natural resources, it might be able to weaken the combined effects of population growth and rising affluence. Assuming the implementation of the same production and provision systems, by 2050 nine billion people will require 180 billion tons of materials, three times the current amounts, and a 70% increase will be needed in food production as estimated by the FAO (Food and Agriculture Organization).

- There is a big gap in material standards of living around the globe. In other words, materials are distributed unequally and approximately in proportion to the nations' human development index (HDI). The group of countries with a high HDI consumes on average 10 times as many materials as the poorest countries and twice the world average.
- The increase in material consumption results in a number of environmental impacts, such as climate change, increased biodiversity loss, waste generation causing water, air, and land pollution; soil and water acidification and eutrophication; and soil erosion.
- Increase in overall consumption has resulted in price fluctuations, speculations and scarcity of some resources. In the coming decades, the availability of critical resources cannot be taken for granted.
- The current prices of many resources do not reflect the real environmental and social costs. For instance, impacts like climate change, pollution, and noise impacts of transport have been neglected, and cheap oil has been fueling the economy internationally for years (Collier 2010). The burden is mostly on developing, resource exporting countries, commonly challenged with political instability and with poorly developed environmental policies.
- Growing scarcity of water and available land are threats to future economic growth. Comparing the productive land available and the needed land, using the ecological footprint indicator, our demand already exceeds the potential of earth.

Definition - Sustainable Material Management

One should bear in mind that Sustainable Materials Management (SMM), should be seen through a sustainable development perspective. That is to say, it is not an independent concept, and is one of many introduced terminologies for representing a sustainable approach for materials use. Since the sustainable development concept gained traction in Rio de Janeiro in 1992, knowledge about the interrelated concepts linked to sustainable development has advanced, leading to the introduction of different terminologies by international bodies, that is, UNEP, EU, and the OECD depending on their particular objectives for policy development. Integrated product policy (IPP), sustainable use and management of natural resources, sustainable consumption and production (SCP) and sustainable materials management (SMM) are some keywords frequently used for presenting the holistic approach for materials management. While the first three are mostly used by the UNEP and EU, SMM is OECD's term for the concept. Meanwhile, in practicing the mentioned management strategies, other concepts have emerged such as life cycle assessment, waste reduction, resource productivity and efficiency, lean production, sustainable product chain, and eco-innovation. Note that, different terminologies do not necessarily mean different things and there often is considerable overlap.

Definition

Sustainable Materials Management is an approach to promote sustainable materials use, integrating actions targeted at reducing negative environmental impacts and preserving natural capital throughout the life-cycle of materials, taking into account economic efficiency and social equity.

Sustainable Material Management Strategies

The sustainable approach for management of natural resources has historically had economic and environmental drivers. Originally, the concept of sustainable materials management was developed in the context of waste policies. A life cycle perspective was believed to be able to minimize environmental impacts of human activities. In other words, sustainable management of materials emerged on the global political agenda well before resource concerns were shaped.

However, the exponential growth of political attention towards sustainable strategies was a consequence of the price volatility of a number of materials. Increased demand for raw materials, especially in developing countries, which are facing both population growth and rising affluence, and inconsistency between supply and demand led to a sudden price rise of a number of materials. Volatile commodity prices and possible scarcities of raw materials preceded financial and economic crisis globally, leaving importing countries vulnerable. Hence, sound waste and resource management was seen as a key strategy for maintaining economic competitiveness.

The concepts of SMM are still evolving. Meaning materials management has held different interpretations through time, gradually maturing and still growing. In order to understand the SMM concept and to be able to evaluate implemented cases, it is necessary to realize the distinction of the evolution stages. SMM needs systems thinking and a holistic perspective. Therefore, it is not shocking that its development has an analogy with organizational learning divide the evolution in materials use into three steps, each matching a learning phase of organizational learning. They relate the evolution in materials management concept to our knowledge of the complexity of ecosystems. Since the late twentieth century we have started understanding the effects of human activity on the ecosystems at large, changing our perspective and way of thinking towards the suitable management approach. Before describing the three stages of development, namely, reaction, redesign, and reframing, it is worthy to mention that, when specifying time periods for each of the stages governing the global perspective; science, market, and policy do not often coincide.

Furthermore, the speed of adaptation is different in various countries.

1. Reaction: As described before, end of pipe thinking governed the material (waste) management agenda, through the 1970s and 1980s. After the environmental destruction resulting from industrialization and population and affluence growth was recognized, the reaction was cleaning up. A shift towards pollution and waste prevention happened during the 1980s, focusing on cleaner technologies. The core of business operations was eco-efficiency, that is, “do more with less.” This is when new management standards were introduced, corporate social responsibility (CSR) evolved and sustainable consumption and production emerged at the global political stage. In addition, the product stewardship concept was introduced, asking the companies to address the economic, environmental, and social issues related to their products or services in the whole supply chain. However, the initiatives from businesses were mostly from a linear perspective and not mainstream.

This stage can be attributed to single loop learning, as C. Argyris describes as a primary level of organizational learning. He defines organizational learning as the detection and correction of error, in which single loop learning addresses “what” has caused the problem. It involves technical repair by defining a routine following existing procedures.

2. Redesigning: With the change of our knowledge and understanding about how human activities are causing challenges like climate change and depletion of natural resources, another shift has happened in the perspective towards materials management. The complexity, interdependency and societal impacts of material use have been realized and it is accepted that the solution is not found in the industrial processes and production efficiency alone. The goal switches from “do more with less” to “do it right from the beginning,” from eco-efficiency to eco-effectiveness. In other words, implementing a life cycle perspective throughout all the steps a material goes through, from extraction, design and production to the end of use stage, becomes crucial. The Cradle to cradle concept is born, thinking of how to keep materials in closed cycles, biologically or technically. This change of view led to a shift towards products services models; from owning (end-user) to using (leasing, renting) in order to reduce environmental pressures.

This shift matches the double loop of organization learning, answering the “how” to solve the problem question, by improving the processes and structures. As more complicated questions arise, creativity is critical in this step.

3. Reframing: Lately, a shift is noticed from linear thinking to complex and circular thinking. All the concepts related to different life cycle stages of materials, are seen as a part of a bigger system which influences other systems: ecology, society, and economy, both for now and the future and beyond the political boundaries. Near the end of the twentieth century the notion of integrative policy was introduced to address not only the technical and environmental issues but also the political, social, financial, economic, and institutional elements of material management. However, it did not address all generations beyond political boundaries, at the very first. The fully integrated, systematic perspective which takes into account all the life cycle stages of a material, beyond generations and geopolitical regions, is the sustainable materials management we are discussing. SMM's evolution has been a product of triple loop learning, which answers "why" the challenge remains by questioning the basic framework. The problem is reframed, new approaches are introduced and a transition to new models begins.

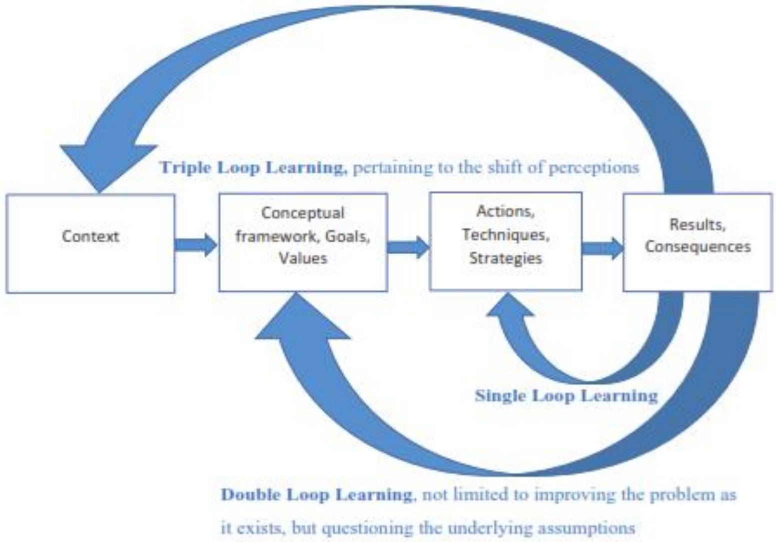


Fig 4.7 Single, double and triple loop learning

Since the industrial revolution, consumption patterns have changed dramatically as a result of population growth and rising affluence. This shift has resulted in environmental depletion, and the growing risk of economic crisis caused by material scarcity. Historically, health and safety drivers have governed waste management practices. However, lately, due to the price volatility of some raw materials, economic drives have resulted in the development of holistic approaches for the management of waste and resources. It is argued that waste management practices have experienced an evolution. Primarily, increasing awareness of the influence of human activities on the environment gave rise to reaction-solutions simply based on cleaning up. However, a shift happened from end-of-pipe thinking to preventative thinking through the 1980s, and new concepts were introduced such as waste minimization, pollution prevention, and toxic use reduction. This stage can be interpreted as engaging double loop learning as defined by C Argyris, that is, redesigning by means of questioning the underlying assumptions. The last paradigm shift as taken place recently: complex and circular thinking has substituted linear thinking. An integrated systematic approach addressing not only technical and environmental concerns but also taking into account societal, political, and economic elements of material management has been introduced. Sustainable materials management is a concept defined consistent with sustainable development, basically representing the inferred holistic approach for managing waste and resources. Different terminologies have been introduced through different global players such as the UNEP, EU, and OECD, which represent quite similar concepts, only slightly different in their scope. In this chapter, the history of SMM is clarified by presenting definitions of the various terminologies used in this field, focusing on their interrelations and answering the question of how comprehensive are they from a sustainable development perspective.

4.5 Policy Framework for Sustainable Waste Management

A waste management system is an essential part of an inclusive environmental management system. A waste management system may be described as the management of all responsibilities, practices, procedures, processes and resources for establishing a system that manages waste and complies with environmental regulations. The term waste generally encompasses an unwanted or unusable material that is intentionally thrown away by its users. Definitions of different types of waste have been clearly stated in the form of law by international organizations such as the United Nations (UN) and the European Union (EU) to precisely classify wastes and minimize the environmental, social or economic downsides of dumping those waste. A waste management system includes the generation of waste, storage, collection, transportation, treatment, processing, recycling and final disposal of garbage, sewage and other waste products. A waste management system may also entail strategies used to avoid or reduce waste generation in the first place.

The ever increasing trend of MSW over the past decades is a case in point where the free market has failed, and where the true cost of our consumption-led lifestyle, particularly the significant environmental cost, is not reflected to each individual. To rectify the problem effectively, we must put the full cost back to our consumption equation, so that each individual can have the right economic incentive to choose a more sustainable way of living that involves producing less waste and recycling more. In this chapter, the Government lays out its approach to achieve sustainability in Municipal Solid Waste (MSW) management by describing the waste hierarchy and explaining how our proposed policy tools in the hierarchy can provide the incentives to induce changes in our behaviour and attitude towards waste.

The Waste Hierarchy

The waste hierarchy is our framework for actions. The waste hierarchy has been the guiding principle for managing MSW worldwide since first introduced. The Government's strategy is to adopt a three-tiered approach in the waste hierarchy, which involves, in descending order of priority:

- Avoidance and minimisation;
- Reuse, recovery and recycling; and
- Bulk reduction and disposal

The three-tiered approach is adopted to achieve sustainable MSW management. The first priority - avoidance and minimisation - is to address the problem at source and to encourage people to reduce waste generation as much as possible. If it is not feasible to avoid generating waste in the first place, the waste generated should be minimised as much as possible, through avenues such as appropriate product design or minimal packaging.

The next priority is to maximise the reuse, recovery and recycling of suitable recyclable materials. To make recycling work efficiently, robust sorting, collection and distribution systems must be in place. Equally important are the market outlets for the recycled materials. In fact, the recycling industry is a key element in a "circular economy", whereby recyclable materials generated in economic activities are returned to the consumption loop as a result of reuse, recovery and recycling. Through the loop of a "circular economy", we could achieve the most efficient use of resources and materials, while producing as little waste as possible.

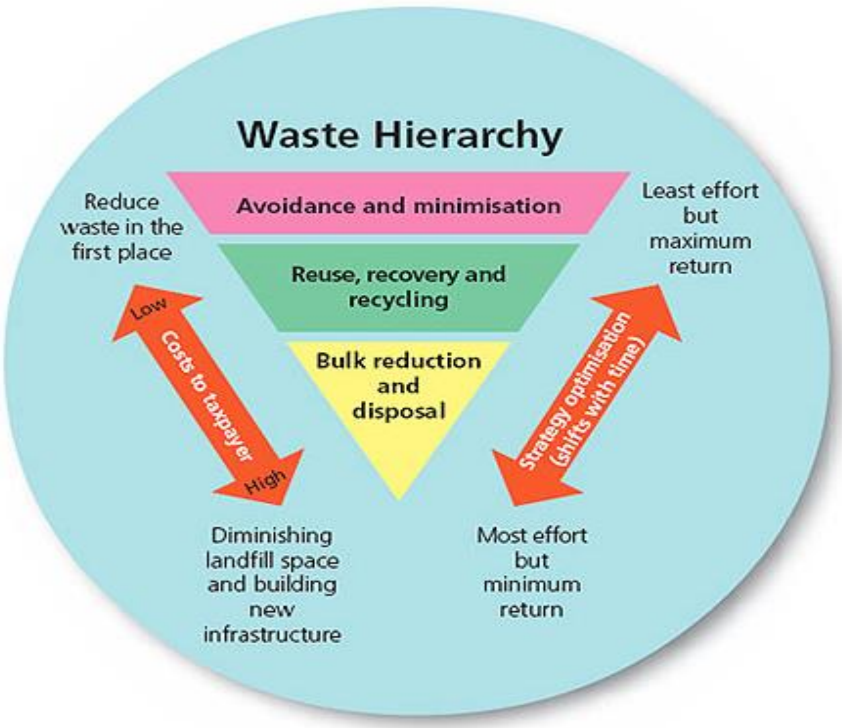


Fig 4.8 The Waste Hierarchy Model

Based on 2004 figures, each of us generates 1.35 kg of waste a day that requires disposal, out of which about 1.0 kg, or 74%, arises from the domestic source. Surveys show that only 14% of domestic waste is recovered, in sharp contrast to the recovery rate of 60% to 70% for commercial and industrial waste. This striking difference results from commercial and industrial waste being generally less diverse and less contaminated than domestic waste, thus more readily separable for recycling programmes. Also, commercial and industrial waste producers are required to pay for collecting and transporting their waste to landfills, thus having the economic incentive to reduce their waste.

Clearly, domestic waste has the greatest potential for improvement in terms of recovery and recycling, and this is exactly where we shall devote our attention and enhance our efforts. With the very low recovery rate for domestic waste, we must take ownership of the problem, and take actions at a personal level.

Once the possibilities of waste avoidance, minimisation and recycling have been exhausted, we must properly treat and reduce the volume of residual waste through appropriate treatment technologies. It is a commonly accepted principle that all waste should be properly treated prior to disposal at landfills to prevent long-term liabilities. The direct disposal of untreated MSW causes leachate and landfill gas (LFG) emission, and would result in long-term environmental burden.

In economic terms, waste avoidance, reduction and recovery generate high return with relatively less investment. The Governments has been working hard on these areas to achieve the most with our limited resources, and continue to do so.

The Role of Policy Tools and Support Measures

Effective policy tools in the waste hierarchy are those that induce appropriate actions and achieve outcomes that further the overall objective of the Policy Framework. In MSW management, the policy tools we propose are meant to encourage waste avoidance and minimisation; waste separation and sorting; reuse and recycling; and bulk reduction and treatment. Each of our proposed policy tools works hand in hand, and aims to generate a knock-on effect that is more than the simple sum of all tools. The proposed policy tools, if implemented, will be supported by both legislation and sustained education programmes to ensure public buy-in and general compliance.

The objectives of the policy are

- To ensure that waste management is performed in accordance with all waste legislative requirements, including the duty of care, and to plan for future legislative changes and to mitigate their effects in accordance with the Environmental Sustainability Policies such as air and water pollution, waste management, biodiversity conservation (The Policy Statement for Abatement of Pollution, 1992; The Forest Policy, 1988).

- To minimise waste generation at source and facilitate repair, reuse and recycling over the disposal of wastes, where it is cost effective in accordance with Sustainability Strategy.
- To provide clearly defined roles and responsibilities to identify and coordinate each activity within the waste management chain.
- To promote environmental awareness in order to increase and encourage waste minimisation, reuse and recycling.
- To secure where possible revenue from recyclable materials to reinvest into the expansion of sustainable wastes management opportunities.
- To ensure the safe handling and storage of wastes.
- To provide appropriate training for staff, students and other stakeholders on waste management issues.
- To promote industry waste management best practice.

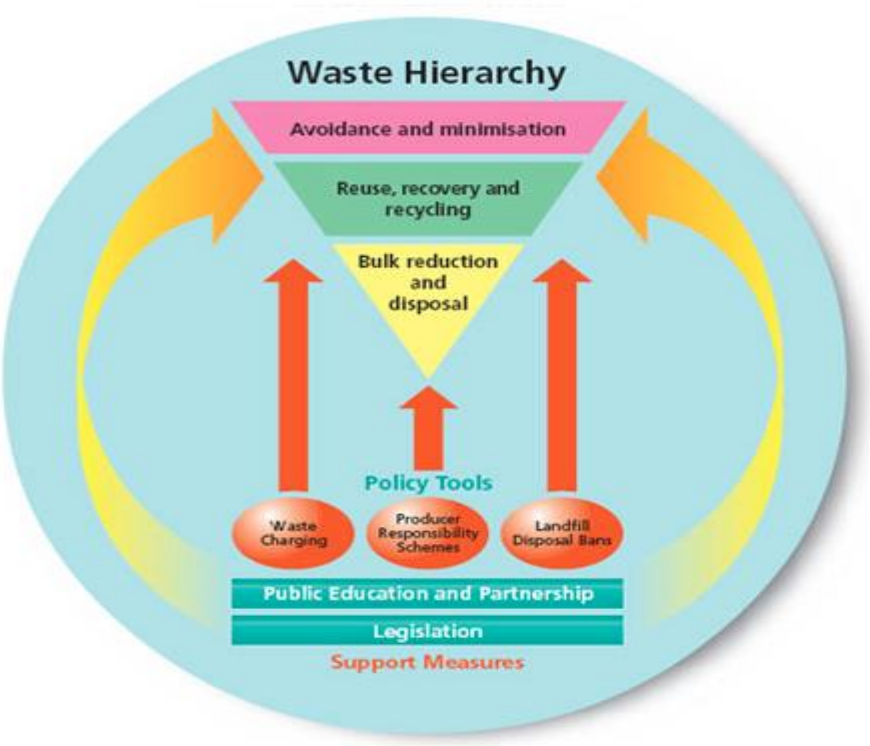


Fig 4.9 The right tools and measures for the right job

Table 4.1: Policy tools and support measures

Proposed Policy Tools	**Waste charging** - provides a significant effect on changing behaviour and puts in place the "polluter-pays" principle
	PRSs (Producer Responsibility Scheme) - put the onus on the producers and users of products (i.e. the community) to share the responsibility for all the economic, social and environmental impacts of a product throughout its lifecycle
	Landfill disposal bans - divert MSW away from premium and expensive landfill space
Support Measures	**Public education and Partnership** - soft measures to raise awareness, increase understanding, and foster partnerships with the community and businesses
	Legislation - necessary to ensure compliance and penalise those who engage in environmentally harmful behaviour and practices.

Waste Charging

MSW management is not free. There are several sound reasons for why waste charging is vital to putting in place an integrated approach to waste management. Citizens do not pay directly for the costs of collecting, handling and disposing of the waste they generate. The annual cost of MSW management, nearly $1.2 billion, comes out of the public purse. Therefore, there are no economic incentives for anyone to reduce the volume of waste, or to reuse or recycle waste.

To establish a clear linkage between consumption and the environmental costs entailed, we propose to impose a direct and explicit charge on each individual for the amount of waste one discards. In other words, the full cost of managing MSW would be placed squarely on those people who generate MSW in the first place. This is fully consistent with the "polluter-pays" principle, which the public generally support. International experience has shown that where waste charges are in operation, the waste volume decreases and the rate of avoidance, as well as recycling, goes up.

Waste charging is a direct tool to change behaviour. A consumption-led lifestyle where out-of-fashion products, whether new or used, are casually thrown away, imposes a huge burden on the waste management infrastructure and is clearly unsustainable. By imposing a direct charge on MSW, people are compelled to rethink their consumption and disposal behaviour and become more conscious about the adverse environmental consequences. They are not only in control of how much they pay for disposing of their waste by exercising a choice on purchasing, but more importantly, to play a part in reducing waste and protecting the environmental well-being of India.

We can pay less by throwing less. Separation of waste at source is pivotal in the Government's strategy to reduce the amount of waste requiring treatment and disposal. By imposing a direct charge on MSW, households are given an economic incentive to separate those recyclable materials from the waste stream, thus lowering the MSW charge they need to pay. Less waste being produced translates into lower long-term waste management costs and less need for landfills and other waste management facilities. The potential of environmental returns is likely to be multi-fold, and the benefits go to both the Government and the community.

Producer Responsibility

A shared responsibility shall be imposed amongst manufacturers, handlers and end-users. Each product has economic, social and environmental impacts at different stages of its lifecycle. We must hold the producers and the users of products responsible for the products they produce and consume. The Government proposes to establish a framework for introducing PRSs for specific products, with priority given to those that have significant impacts on waste disposal, in either how they are produced, packaged, consumed or after the end of their lifespan.

PRSs place the obligation for managing certain products on the producers, distributors or sellers of the products. A well-designed PRS spurs producers to design products that generate less waste, or that can be reused or recycled. Extended PRSs extend the concept further to a shared responsibility for all the economic, social and environmental impacts of a product throughout its lifecycle among consumers, the industries and the distributors that are involved in that product. We want not only the commercial and the industrial sectors to rethink the way they approach a product from design to disposal, but also consumers to make wise decisions on purchasing, reuse and disposal of products.

PRSs play a key role in sustaining a dynamic local recycling industry. In a "circular economy", waste generated as a result of economic activities is returned to the consumption loop. Recycling not only slows down the rate of depletion of natural resources, but also reduces the pollution from manufacturing activities. Over the years, we have made significant headway in recycling. As much as 2.3 million tonnes of MSW are recovered as recyclable materials annually. Yet, 90% of these materials are exported for recycling, working against the proximity principle and subjecting ourselves to volatile global demand. By establishing a long-term, stable and local source stream of recyclable products and materials through PRSs, the Government hopes to develop and sustain the local recycling industry that puts the concept of a "circular economy" in practice.

Landfill Disposal Bans

Landfill disposal bans protect our precious landfills. Biodegradable wastes like kitchen and restaurant waste are known to create LFG and leachate. LFG is malodorous and potentially suffocating, flammable and explosive. Leachate is highly polluting and, if not properly controlled, may seriously contaminate water bodies through infiltration or direct discharge of leachate. The decomposition of biodegradable waste is a slow and non-homogenous process. This results in differential settlement of the landfill surface that may lead to slope instability problems for many years. In fact, the total cost of maintaining some 300 ha of closed landfill sites to address their environmental problems amounts to $62 million per year. We must save our precious landfill capacity and reserve it for inert or unavoidable waste. A ban on biodegradable waste, proposed to be introduced in the longer term, allows landfills to last longer and makes them less of a long-term environmental burden. Such ban is also in line with overseas practices such as the EU Landfill Directive, which lays down progressively lower limits on the biodegradable content of landfilled waste.

Landfill disposal bans have sound economic reasons. They not only ease the pressure on landfill space, but also ensure a stable and long-term source of recyclable materials for the recycling industry or the second-hand goods market. They will focus on products that can easily be separated from the main waste stream and have a recycling value or proper treatment outlets. Other than the recovery of valuable materials, the landfill disposal bans tie in with the Government's overall MSW management strategy that emphasizes waste avoidance, reduction, reuse and recycling. They complement MSW charging and PRSs to ensure that certain waste types are recovered.

Public Education and Partnership

Public education and partnership form the foundation of our policy tools. To implement the proposed policy tools successfully, the community's full support is crucial. People must understand the need to change old practices and appreciate the advantages of our policy tools. Appeals and advertising campaigns help to raise awareness, but the greatest impacts have come through a more direct approach - by reaching out. A sustained, community-wide education and partnership programme will play a significant and long-term role in reinforcing the importance of MSW avoidance, reduction, reuse and recycling.

We must target the young by starting at schools. A key agent of change is the education sector, where our future generations are nurtured. The development of responsible behaviour and environmentally friendly habits will hinge upon inculcating in students civic awareness and social responsibility to care about our environment through waste reduction. School curriculum plays an important role in developing responsible behaviour, which can be promoted through moral and civic education, environmental education as well as subjects such as General Studies at the primary level, Social Studies, Liberal Studies, Integrated Humanities and Science subjects etc. at the secondary level. Garbology is an emerging applied science linking research, technology, and management of wastes.

Partnerships with the business community are critical. Businesses are important partners in MSW management. The well-celebrated WasteWise in Hong Kong initiative has encouraged and recognised thousands of businesses that proactively reduce their waste. Through the participation of the business community, we can demonstrate to the wider public how our policy tools can really work, and instill the concept of Sustainable Waste Management in our strong labour force.

Legislation

Legislative backing for the policy tools is needed. The Government must be firm and fair, and legislative backing for our proposed policy tools is indispensable. Once legislation is enacted, regulatory measures will be put in place to ensure that MSW charging, PRSs and landfill disposal bans are complied with. Monitoring and enforcement will deter and penalize those environmentally harmful practices such as "fly-tipping" and ensure that products and materials are properly recovered for reuse or recycling.

Summary

- Avoidance and minimisation; reuse, recovery and recycling; and bulk reduction and disposal.
- Generate the highest return with our limited resources, the Government's efforts focus on waste avoidance and recovery.
- Waste charging promotes the "polluter-pays" principle and provides economic incentives to induce behavioural changes
- EPR emphasize the shared responsibility and provide an added incentive to recover and recycle, thus sustaining a dynamic local recycling industry.
- Landfill disposal bans prevent valuable, recyclable and unstable MSW from entering landfills so as to extend their usable life, reduce long term environmental burden and complement the first two policy tools.
- Policy tools - waste charging, EPR, and landfill disposal bans - and the two key complementary measures - public education and partnership and legislation - would work hand in hand and have a knock-on effect.
- Responsible Consumption and Production goal in the SDGs emphasizes the sustainable waste management.

To Do Activities

Paper Presentation

1. Identify your local municipality waste management practices and identify gaps and giver recommendations to implement Sustainable Waste Management strategies, specific to local.
2. In the food and beverages industry explore the possibility and implementation strategy for EPR.

Chapter 5 - Resource Recovery

Introduction

There is a growing perception change in looking at waste as a resource. Resource recovery is using wastes as an input material to create valuable products as new outputs. The aim is to maximise the recovery potential of perceived waste thereby reducing the need for landfill space. Resource recovery delays the need to use virgin materials in the manufacturing process. Materials found in municipal solid waste can be used to make new products. Plastic, paper, aluminium, glass and metal are examples of where value can be found in waste. Resource recovery is the separation of certain materials from the waste we produce, with the aim of using them again or turning them into new raw materials for use again.

The core success of Resource Recovery largely depends on identification and assessment of potential of material to use as secondary resource to produce new generation of products, while eliminating the toxic hazard. It involves composting and recycling of materials that are heading to the landfill. Conventionally, waste is collected without segregation and sent them to a landfill. Every landfill has a fixed lifespan, and country witnessed pressure for new and acceptable landfill sites – with growing '*Not in my backyard*' resistance from communities, with additional cost of transportation and intensifying the impact of climate change. Recourse recovery strategies help address this concern and the tax on transporting to distant locations. Recourse Recovery offers optimal solution addressing resource scarcity, environmental hazards and other escalating costs centered in landfill operations. Improvements to administration, source separation and collection, reuse and recycling practices are essential through a decentralized recovery system.
Recovery process is not a simple, and linear and calls for commitment at governance level, combined with strategic planning, appropriate technologies, effective extension education outreach programs, and active community participation. Such as approach ensures long-term environmental and economic benefits.

Objective

The objective of this block is to improve the understanding and knowledge of students on the scope of resource recovery in diverse sectors. To provide insights on available technologies, and methods - brings awareness on application in emerging sectors. To build confidence in management perspectives towards sustainable implementation systems.

5.1 Resource Recovery and Sanitation

To-date, sanitation and waste management has mainly been approached from a public and environmental health perspective and this implies that excreta and other organic waste streams are seen not only as a hazard to quickly get rid of but also as only a very costly menace to manage. However, looking at sanitary and other urban organic waste streams from a resource recovery perspective provides an avenue for solutions with multiple co-benefits. Revenues from reuse products can act as an incentive for improving sanitation and waste management infrastructure while also covering part or all of the investment and operation costs for the same. Until now, estimating the potential for resource recovery from sanitation systems and technologies has been largely done on a case by case basis according to project or geography with no standardized universal tools or methodologies being used across the world.

Unsafe management of excreta and wastewater expose populations to disease, and degrade ecosystems and the services they provide. At the same time, there is growing recognition that societies can no longer afford to squander the water, nutrients, organic matter and energy contained in sanitation and other wastewater and organic waste streams. These resources can, and should, be safely recovered and productively reused. In fact, the vision of resource efficient, circular economies is unachievable without radical change in how we manage wastewater, excreta and other biomass waste.

To put the scale of the opportunity into perspective, globally we produce an estimated 9.5 million m^3 of human excreta and 900 million m3 of municipal wastewater every day (Mateo-Sagasta et al. 2015). This waste contains enough nutrients to replace 25 per cent of the nitrogen currently used to fertilize agricultural land in the form of synthetic fertilizers, and 15 per cent of the phosphorus, along with enough water to irrigate 15 per cent of all the currently irrigated farmland in the world (some 40 million hectares). At the city scale, the wastewater (including excreta) from a city of 10 million people contains enough recoverable plant nutrients to fertilize about 500,000 hectares of farmland – which in turn could produce about 1.5 million tons of crops.

Nutrient Recovery from Waste Waters

In the past, wastewater was considered a nuisance stream, requiring treatment before being discharged to receiving bodies of water. As the scarcity and price of clean drinking water continue to rise across the world, the value of wastewater, for its recoverable water content is also increasing. Presently, the paradigm of wastewater is changing. Now wastewater is being viewed as a resource based on recoverable components such as nutrients, carbon, and inorganics in addition to water and energy.

Synergies for this paradigm change exist in several aspects. New wastewater discharge regulation of nutrients such as phosphate for example, is in sync with world market demand of phosphate. Water reuse and recovery as well as energy recovery for WWTFs are providing concentrated waste streams which make recovery of wastewater components much easier than before. Technologies which focus on resource recovery are in operation and are under development for some of the many components in wastewater.

There are new technologies and emerging technologies that are designed to produce or improve the resource value of wastewater, including better treatment technologies to produce various levels of reclaimable/reusable water, technologies to recover nutrients (N, P, and S), processes to produce marketable biopolymers and biodiesel during the wastewater treatment, energy recovery from heat-pumps (not associated with anaerobic digestion), and metals recovery from process residuals.

The recovery of phosphorus from domestic wastewater has been implemented at full-scale installations (Ostara process, Crystallactor, Phosnix processes, to name a few). These processes have the ability to remove and recover over 85% of the soluble phosphorus in the water. Crystal/ pellet sizes range from 0.5 mm to 5 mm and above. The size range may be important for final end use, such as, larger pellets for agricultural use and smaller for nutrient enhancement of water bodies. Although some utilities in North America have installed these systems, the uptake of these technologies has not been widespread, due to market, regulatory, and site-specific conditions.

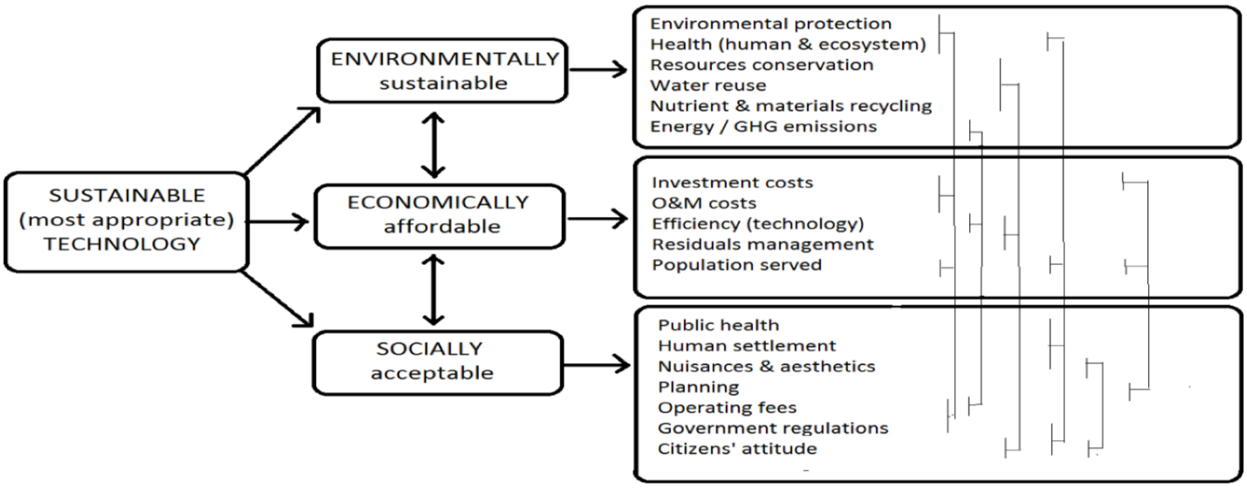


Fig 5.1 Resource Recovery Implementation Model

In recent years, the focus has included recovery of nutrients from source-separated urine as well as dairy wastewater. Many pilot projects on new sanitation methods (e.g., source separated urine) have been completed in Europe with full scale application constructed for black and grey water treatment in Sneek, the Netherlands. The latter source (dairy and other animal wastewater) is of immense value as the quantity of nutrients per mass of waste is many times that of domestic wastewater. However, research is still in an embryonic stage due to the requirement of pre-treatment of the waste prior to recovery. There are opportunities to collaborate with the agricultural sector, although significantly greater efforts to communicate between the two sectors are needed.

There is growing interest (and facilities being built) to produce "products" derived from sewage or sewage sludge. They include agricultural crops grown with effluent applied to the land as a part of "land treatment systems", such as forage crops and small grain crops being grown on sites receiving secondary effluent as a part of systems designed to provide advanced treatment. Highly treated effluents are "reused" as a water supply to irrigate various crop types, including vegetables and greens consumed raw. There are also aquatic plants, such as algae and duckweed, that grow naturally as a part of pond and lagoon treatment systems, and in some cases systems have been developed to use effluent as a water supply and nutrient source to grow algae and/or duckweed as a crop that is harvested and used for a variety of purposes, including biofuels, a source of protein for animal feeds, etc.

Table 5.1 Estimated excretion of nutrients per capita in different countries

Country	Nitrogen (kg/capita/yr)			Phosphorus (kg/capita/yr)			Potassium (kg/capita/yr)		
	Urine	*Faeces*	Excreta	*Urine*	*Faeces*	Excreta	*Urine*	*Faeces*	Excreta
China	3.5	0.5	**4.0**	0.4	0.2	**0.6**	1.3	0.5	**1.8**
Haiti	1.9	0.3	**2.1**	0.2	0.1	**0.3**	0.9	0.3	**1.2**
India	2.3	0.3	**2.7**	0.3	0.1	**0.4**	1.1	0.4	**1.5**
South Africa	3.0	0.4	**3.4**	0.3	0.2	**0.5**	1.2	0.4	**1.6**
Uganda	2.2	0.3	**2.5**	0.3	0.1	**0.4**	1.0	0.4	**1.4**

For example, in the U.S., there are thousands of wastewater treatment ponds and lagoons that are functionally high rate algae producers. In some cases, these wastewater treatment ponds and lagoons develop a mat of duckweed on the surface. Research institutes in India, initiated some years ago, evolved from duckweed growing naturally on many wastewater stabilization lagoons into systems designed to maximize production (and harvesting) of duckweed as a part of systems to polish nutrients from pretreated wastewater effluents. In more recent years systems have been designed to grow specific types of algae which produce oil to be converted to biodiesel fuel. National Environment Engineering Research Institute NEERI, for example, provides a range of pond-based biological treatment systems for municipal and industrial effluents that involve algae and duckweed production, covers, harvesting equipment, conversion to biogas, etc. Duckweed-based wastewater treatment systems overseas incorporate additional beneficial use options as animal feed, fish production, etc. There is growing interest in culturing and harvesting algae for use in biofuels production and to combine these efforts with wastewater treatment systems, including the treatment of on-farm animal wastes.

Processed sewage sludge materials (e.g., composted biosolids, alkaline stabilized biosolids, and heat dried pellets) are used for such purposes as a land applied soil amendment product and/or as a source of fertilizer, and in recent years as a possible supplemental fuel source. There are examples of products derived from sewage sludge, including bricks produced using biosolids as an additive to the main clay mix that is "fired" to produce the bricks; the conversion of sewage sludge to crude oil, char, and other petroleum products. More recently, biodiesel produced at wastewater treatment facilities and biogas from anaerobic digesters have been used as fuel for fleet vehicles. Recovery of a wide range of metals and other in organics (phosphorus, iron, aluminum, zinc, magnesium, nickel and manganese) as well as precious metals such as palladium, gold and silver; and even the extraction of various organics and proteins have also been reported.

Scope for Efficient Nutrient Recovery

1. Markets and application of recovered product: It has been determined that nutrients can be recovered from wastewater (e.g., with technologies to recover phosphorus as struvite). But what is not known, or what has yet to be determined, is what are the specific markets and applications (as well as the quality and true costs) for some of the resources. Markets and application of recovered product

- Necessary to determine if there are economic and environmental benefits and deficits associated with converting the plants from a treatment paradigm to a resource recovery paradigm. Once this question can be answered, then plant personnel will be able to make informed decisions on whether to take the next step towards nutrient recovery.
- Potential nutrient trading among different stakeholders (such as between wastewater treatment plants and users of recycled water from wastewater) in developing technologies.
- There is a worldwide loss of topsoil which is crucial to ecosystems and for sustaining food production. Returning organics from wastewater to agriculture alleviates this loss and is thus an important component.

2. Product quality: Most of the processes employed worldwide recover phosphorus and nitrogen in the form of struvite and/or Ca-phosphate pellets. However, not all the products are of high quality in terms of pellet characteristics such as crushing strength, size, and bacteriological quality. It is necessary to determine methods to improve and measure the physical quality of the recovered products. Studies related to improvement of crushing strength and pellet size are ongoing at the University of British Columbia and other research institutes globally.

3. Identification of recoverable products from some wastewater streams, particularly supernatants from anaerobic digestion:

- Only a fraction (5-15%) of the available nitrogen in the wastewater can be recovered through phosphate based precipitates. There may be other potential resources that can be recovered along with P/N recovery or in a subsequent process. We need to develop technologies that perform multiple resource recovery tasks.
- Need to identify other (all) resources that may be recoverable from some WW streams.

4. Technological developments

- How can the current processes be developed or improved further to increase recovery efficiency and product quality.
- Are the reactors in use the most efficient? Is there a different reactor configuration that can be developed?
- What are the true environmental and public health concerns associated with water reuse, bio solids reuse, reuse of recovered resources in general? Need to calculate the potential GHG reduction from nutrient recovery.
- We need to develop technologies for higher recovery of nitrogen from wastewater.
- Ammonia recovered from wastewater can potentially be used as an energy source. We need to find ways to get the hydrogen out of the ammonia. Need to find if there is a market for this.
- Need to develop methods to quantify and improve product quality and quantity.
- Recover nutrients from dairy wastewater is limited in application. We need to find pre-treatment methods so that the effluent can be used for recovery.
- Use of microwave and other sludge busting technologies to release increased amounts of nutrients. More pilot-scale trials need to be carried out.

There is growing global recognition that wastewater is a renewable ("green") resource with value added products such as water, energy, and nutrients in solid or liquid form. The water quality industry is expanding their prior focus from stewardship of public health and ecosystems to leadership to address shortages of Nutrients, Energy, and Water to sustain rising global populations, meet increased food production demands, and reduce costs. These "N-E-W" issues have also been identified as key priority areas by several water research organizations. There is growing realization that the linear, one-pass approach of collecting, treating, and disposing wastewater is not sustainable and that non-linear, closed loop systems are more viable in urban areas which represent more than half of the world's population and is of growing importance globally.

5.2 Waste to Energy

Inefficient disposal of waste in large quantities chokes landfills and water bodies, ultimately resulting in health and environmental issues. Low and middle income countries lack adequate infrastructure and technology required for efficient solid waste treatment. Mixed waste is particularly difficult to treat due to heterogeneity and lack of suitable technology. All waste, therefore, ends up, in landfills and open dumps, and poses risks of garbage fire and choking water channels. Alternatively, it is incinerated, which often causes air pollution and deteriorates the environment. Untreated waste causes huge environmental impact on wildlife, ecosystems and to human health.

Growing population, increased urbanization rates and economic growth are dramatically changing the landscape of domestic solid waste in terms of generation rates, waste composition and treatment technologies. A recent study by the World Bank (2012) estimates that the global MSW generation is approximately 1.3 billion tonnes per year or an average of 1.2 kg/capita/day. It is to be noted however that the per capita waste generation rates would differ across countries and cities depending on the level of urbanization and economic wealth.

The amount of municipal solid waste generated is expected to grow faster than urbanization rates in the coming decades, reaching 2.2 billion tons/year by 2025 and 4.2 billion by 2050. Today, the majority of MSW is generated in developed countries (North America and European Union. However, the fastest growth in MSW generation for the coming decade is expected mainly in emerging economies in Asia, Latin America and South Africa. In terms of waste composition, there is a shift towards an increased percentage of plastic and paper in the overall waste composition mainly in the high-income countries, as shown in Figure 3 (UNEP, 2010). It is expected that both middle- and low-income countries would follow the same trends with the increase of urbanization levels and economic development in these countries.

Much of this waste, however, retains value, and can be recycled and reused. Significant amount of waste can produce energy that replaces expensive fuels. In recent years, research and development efforts have resulted in many waste treatment solutions that generate energy from landfill-bound waste. Waste-to-Energy enterprises bring innovative technologies aimed at addressing waste while ensuring better sustenance of the environment and minimum damage to the ecosystems. The two major types of waste-to-energy technologies are on-site (decentralized energy generation near the source of waste) and off-site (centralized waste generation away from the source of waste). These technologies produce energy products such as briquette and biogas for heating and cooking purposes and electricity generation. A few enterprises have also invented technology to convert plastic waste into petroleum-based fuel.

Waste-to-Energy (WtE) technologies consist of any waste treatment process that creates energy in the form of electricity, heat or transport fuels (e.g. diesel) from a waste source. These technologies can be applied to several types of waste: from the semi-solid (e.g. thickened sludge from effluent treatment plants) to liquid (e.g. domestic sewage) and gaseous (e.g. refinery gases) waste. However, the most common application by far is processing the Municipal Solid Waste (MSW) (Eurostat, 2013). The current most known Waste to energy technology for MSW processing is incineration in a combined heat and power (CHP) plant.

MSW generation rates are influenced by economic development, the degree of industrialisation, public habits, and local climate. As a general trend, the higher the economic development, the higher the amount of MSW generated. Nowadays more than 50% of the entire world's population lives in urban areas. The high rate of population growth, the rapid pace of the global urbanisation and the economic expansion of developing countries are leading to increased and accelerating rates of municipal solid waste production (World Bank, 2012). With proper MSW management and the right control of its polluting effects on the environment and climate change, municipal solid waste has the opportunity to become a precious resource and fuel for the urban sustainable energy mix of tomorrow: only between 2011 and 2012, the increase of venture capital and private equity business investment in the sector of waste-to-energy - together with biomass - has registered an increase of 186%, summing up to a total investment of USD 1 billion (UNEP/Bloomberg NEF, 2012). Moreover, waste could represent an attractive investment since MSW is a fuel received at a gate fee, contrary to other fuels used for energy generation, thus representing a negative price for the Waste to energy plant operators (Energy Styrelsen, 2012).

However, an increasingly demanding set of environmental, economic and technical factors represents a challenge to the development of these technologies. In fact, although Waste to energy technologies using MSW as feed are nowadays well developed, the inconsistency of the composition of MSW, the complexity of the design of the treatment facilities, and the air-polluting emissions still represent open issues for this technology.

The development of Waste to energy projects requires a combination of efforts from several different perspectives. Along with future technical developments, including the introduction in the market of alternative processes to incineration, it is nowadays crucial to take into account all the social, economic and environmental issues that may occur in the decision making process of this technology.

Waste to Energy - Technical and Economic Considerations

Waste to energy technologies are able to convert the energy content of different types of waste into various forms of valuable energy. Power can be produced and distributed through local and national grid systems. Heat can be generated both at high and low temperatures and then distributed for district heating purposes or utilized for specific thermodynamic processes. Several types of biofuels can be extracted from the organic fractions of waste, in order to be then refined and sold on the market.

As of today, the most common and well-developed technology is in the form of Combined Heat and Power plants, which treat Municipal Solid Waste - and possibly a combination of industrial, clinical and hazardous waste, depending on the system settings - through an incineration process. Technical and economic considerations will be therefore limited to this type of plant.

Thermo-chemical conversion

Looking at thermo-chemical conversion processes, in which the energy content of waste is extracted and utilized by performing thermal treatments with high temperatures, the choice of fuel strongly determines the type of process.

- Incineration: With mixed waste input, simple incineration is often utilized by means of the previously described CHP plant technology.

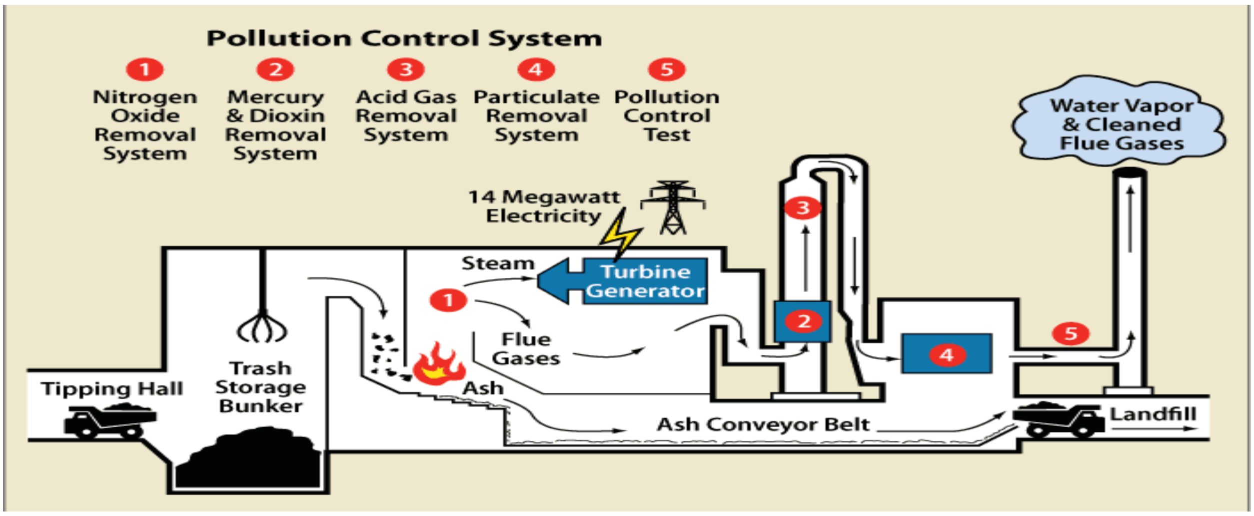


Fig 5.2 Incineration process

- Co-combustion: Co-combustion with another fuel (typically coal or biomass) is an alternative that makes it easier to control the thermal properties of the fuel; in particular the Lower Heating Value. Also, co-combustion is an attractive alternative to simple coal combustion both in terms of costs and emission levels (Rechberger H., 2011).
- Residual Derived Fuel (RDF) Plant: The possibility to achieve higher energy contents is the main advantage of Refuse-Derived Fuel (RDF), which can be achieved from different kinds of waste fractions. Its high and uniform energy content makes it attractive for energy production, both by mono-combustion and co-combustion with MSW or coal (Rotter S., 2011).
- Thermal Gasification: Thermal gasification is a process which is able to convert carbonaceous materials into an energy-rich gas. When it comes to gasification of waste fractions, it is often agreed that this technology is not yet sufficiently developed in comparison to combustion. However, this process could present many favorable characteristics such as an overall higher efficiency, better quality of gaseous outputs and of solid residues and potentially lower facility costs (Astrup T., 2011). Thus gasification, with proper future technology developments, could be considered a valuable alternative to combustion of waste

By definition, waste incineration is carried out with surplus of air. This process releases energy and produces solid residues as well as a flue gas emitted into the atmosphere. Because of emission and safety concerns, there is a certain temperature range that is demanded for this type of process. In the case of mixed waste, a furnace temperature of 1050°C is required. A generic description of an incineration process is represented in the following figure (Figure 1). As depicted in Figure 1, waste is first deposited and then extracted from a bunker, and then it is processed on a moving grate in order to achieve a correct combustion. Before undergoing the combustion phase, the incoming waste may be exposed to pre-treatment, depending on its quality, composition and the selected incineration system.

The combustion products (flue gases) then exchange heat in a boiler, in order to supply energy to a Rankine cycle. This cycle will then provide power and heat by activation of a turbine and by means of a heat exchanger respectively. The choice of the boiler type is strictly related to the choice of the desired final use of the produced energy.

Within the incineration plant, the flue gas cleaning system (which can be designed in different ways - from filters to electrostatic precipitators) and a series of fans ensure both a correct combustion process and controlled emissions. However, there will be a certain percentage of substances emitted into the atmosphere, depending on the MSW composition and on the type of cleaning systems used.

The common pollutant particles in the flue gas are CO_2, N_2O, NO_x, SO_x and NH_3.

Furthermore, it is possible to achieve energy recovery within the cleaning system, when focusing on the flue gas flow. Apart from flue gases that are used to produce heat and power in the incineration plant, the other main product of the process consists of solid residues, mostly in the form of bottom ash or slag and fly ash; some of which can be reused in applications such as filling in the building and construction industries.

The efficiencies for the described incineration process, in terms of energy production, are typically around 20-25% if operating in CHP mode and up to 25-35% in the case of power production only. The size of CHP plants can vary significantly, both in terms of waste input capacity and of power output. A typical capacity is of one (or few) process units, each one dealing with 35 tonnes/hr of waste input (Energinet, 2012). According to the Energy Styrelsen report about Technology Data for Energy Plants (2012), the best example of available Waste to energy incineration technology is the AfvalEnergieBedrijf CHP plant in Amsterdam, in operation since 2007. It is the largest incineration plant in the world (114.2 MW) and is able to process 1.5 million tonnes of MSW per year with an electricity generation efficiency of 30%.

Bio-chemical Conversion

Energy can also be extracted from waste by utilizing bio-chemical processes. The energy content of the primary source can be converted, through bio-decomposition of waste, into energy-rich fuels which can be utilized for different purposes.

- Bio-ethanol production: Bio-ethanol can be produced by treating a certain range of organic fractions of waste. Different technologies exist; each of which involving separate stages for hydrolysis (by enzymatic treatment), fermentation (by use of microorganisms) and distillation. Other than bioethanol, it is possible to obtain hydrogen from the use of these technologies, which is a very useful and promising energy carrier (Karakashev D. &Angelidaki I., 2011)
- Dark fermentation and Photo-fermentation producing bio-hydrogen: Dark fermentation and photo-fermentation are techniques that can convert organic substrates into hydrogen with the absence or presence of light, respectively. This is possible because of the processing activity of diverse groups of bacteria. These technologies can be interesting when it comes to researching valuable options for waste water treatment (Angenent et al., 2004).

- Biogas production from anaerobic digestion: Anaerobic digestion is a biological conversion process which is carried out in the absence of an electron acceptor such as oxygen (Angelidaki I. &Batstone D.J., 2011). The main products of this process are an effluent (or digest) residue and an energy-rich biogas. The entire conversion chain can be broken down into several stages (Figure 5), in which different groups of microorganisms drive the required chemical reactions. The obtained biogas can be used either to generate power and heat or to produce biofuels. The digest can also be utilized in many different ways depending on its composition. Several technologies utilizing this process have been developed throughout the years but are still considered to be immature and not economically competitive compared to other WtE technologies.

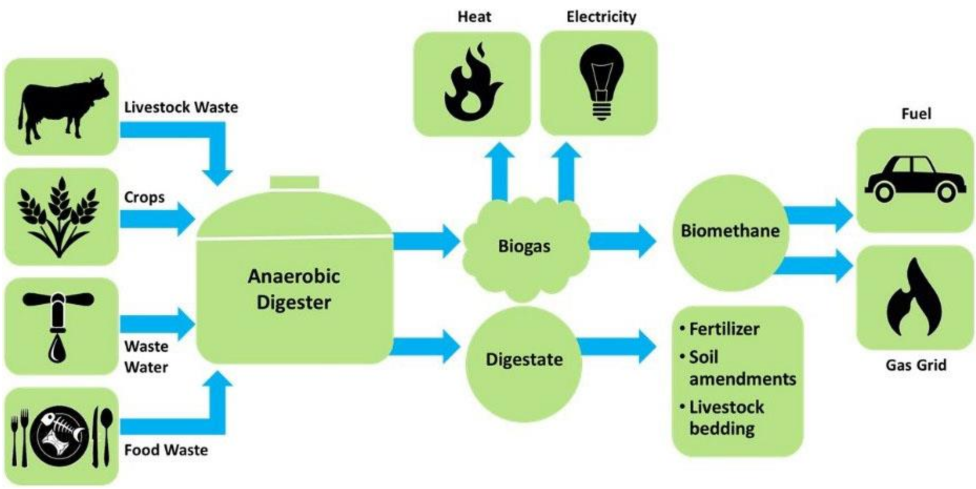


Fig 5.3 Biogas Digester

- Biogas production from landfills: Other than in an anaerobic digester, it is possible to extract biogas directly from landfill sites, because of the natural decomposition of waste (Tchobanoglouset al., 2002). In order to do so, it is necessary to construct appropriate collecting systems for the produced biogas. Biogas in landfills is generally produced by means of complex bio-chemical conversion processes, usually including different phases like Initial Adjustment, Transition Phase, Acid Phase, Methane Fermentation and Maturation Phase (Zaman, 2009).
- Microbial fuel cell: A microbial fuel cell is a device that is able to produce electricity by converting the chemical energy content of organic matter. This is done through catalytic reaction of microorganisms and bacteria that are present in nature. This technology could be used for power generation in combination with a waste water treatment facility (Min B., Cheng S. & Logan B.E., 2005).

Biogas Generation, Purification and Bottling – Case Study

India is implementing one of the World's largest programme in renewable energy. The country ranks second in biogas utilization. Biogas can be generated and supplied round the clock in contrast to solar and wind, which are intermittent in nature. Biogas plants provide three-in-one solution of gaseous fuel generation, organic manure production and wet biomass waste disposal/management.

Biogas is a product of bio-methanation process when fermentable organic materials such as cattle dung, kitchens waste, poultry droppings, night soil wastes, agricultural wastes etc. are subjected to anaerobic digestion in the presence of methanogenic bacteria. This process is better as the digested slurry from biogas plants is available for its utilization as bio/organic manure in agriculture, horticulture and pisci-culture as a substitute/supplement to chemical fertilizers. In contrast, when biomass is subjected to combustion/gasification process, it ends up in the destruction of biomass and only ash is left after extraction of energy. Therefore, the bio-methanation process of converting biomass into gaseous fuel is superior and a sustainable process that needs to be preferred for such biomass materials that can be processed in biogas plants.

Biogas Composition and Properties

Biogas comprises of 60-65% methane, 35-40% carbon dioxide, 0.5-1.0% hydrogen sulphide, rests of water vapors etc. Biogas is non-toxic, color less and flammable gas. It has an ignition temperature of 650 - 7500C. Its density is 1.214kg/ m3 (assuming about 60% Methane and 40% CO2). Its calorific value is 20 MJ/m3 (or 4700 kcal.). It is almost 20% lighter than air. Biogas, like Liquefied Petroleum Gas (LPG) cannot be converted into liquid state under normal temperature and pressure. It liquefies at a pressure of about 47.4 Kg/cm2 at a critical temperature of -82.10 c. Removing carbon dioxide, Hydrogen Sulfide, moisture and compressing it into cylinders makes it easily usable for transport applications & also for stationary applications. Already CNG technology has become easily available and therefore, bio-methane (purified biogas) which is nearly same as CNG, can be used for all applications for which CNG are used. Purified biogas (bio-methane) has a high calorific value in comparison to raw biogas.

Application of Bottled Bio-gas: The purity of biogas is more than 90% Methane and this has being corroborated through tests conducted by National Accreditation Board for Testing and Calibration Laboratories (NABL) and compressed to 150 bar pressure for filling in cylinders.

The purified biogas is equivalent /similar to CNG. The purified biogas is filled in CNG cylinder and supplied to mid-day meal scheme, mess, Hotel, industries etc. for various purposes such as cooking & heating etc.. Calorific value of purified biogas is equivalent / similar to CNG. As a matter of fact, the biogas bottling plants are one of the most potent tools for mitigating climatic change by preventing black carbon emission from biomass chulha since biogas is used as a cooking fuel and methane emissions from untreated cattle dung and biomass wastes are also avoided. The purified biogas can be bottled in CNG cylinders and wherever CNG is currently used, biogas bottling can be used as an alternative.

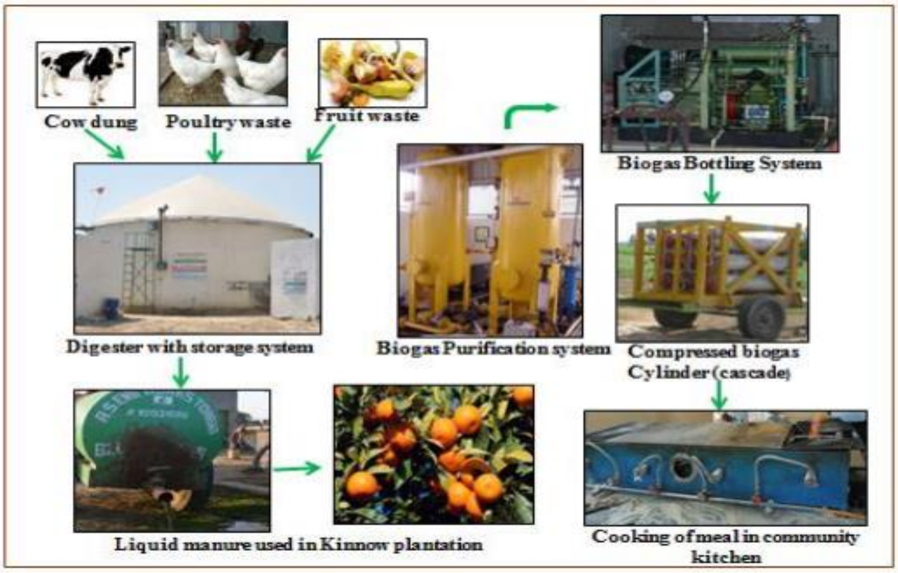


Fig 5.4 Bottled Biogas Manufacturing Process

The slurry which comes out of the biogas plant is directly or after drying used as bio/organic manure for improving soil-fertility and reducing use of chemical fertilizers. It is also non-pollutant because it is free from weed-seeds, foul smell and pathogens. The slurry is rich in main nutrients such as Nitrogen, Potassium and Sodium (NPK) along with micronutrients - Iron & Zinc etc. As such there is no pollution from biogas plant. The slurry/manure of biogas plant is being sold to the farmers and used in liquid/solid form by them in agricultural crops. The field trials have indicated the excellent growth in agro-production and substantial improvements in the quality.

Payback Period: The Biogas bottling project of 1000m3 /day capacity installed at Singla Bio-Energy, Vill.–Siaghawali, Teh.-Sadulsehar, Dist.–Sri Ganganagar (Rajasthan) with the investment of Rs. 1.95 crore by the promoters. The viability of the project is given below

Table 5.2 Biogas Financial Viability

IV	**Payback Period**	
1	Without subsidy	5 to 6 years
2	With subsidy	3 to 4 years
Sl. No.	**Particulars**	**Amount (Rs. in lakh)**
I	**Expenses in one month**	
1	Raw Materials	1.55
2	Electricity	0.12
3	Labour	0.64
4	Bank loan & interest	3.75
5	Miscellaneous	0.83
	Total	6.89
II	**Income in one month**	
1	Compressed Biogas	8.05
2	Organic Manure	1.75
	Total	9.80
III	**Profit**	
1	Monthly	2.91
2	Annually	34.92

Conclusion

As a matter of fact, the biogas-bottling plants are one of the most potent tools for mitigating climatic change by preventing black carbon emission from biomass chulha since biogas is used as a cooking fuel and methane emissions from untreated cattle dung and biomass wastes are also avoided. The purified biogas can be bottled in CNG cylinders and wherever CNG is currently used, compressed biogas (CBG) can be used as an alternative.

There is a vast potential for the production of biogas in the country. In addition to the energy production, biogas plants also provide bio-manure and are helpful in dealing with the problems of waste management, providing clean environment and mitigating pollution in urban, industrial and rural areas. Biogas is also a prominent alternative to petroleum fuel like LPG, CNG and diesel.

5.3 Wastewater Reuse

Given the common situation of public financed wastewater collection and treatment, the term "business models" might appear to be an oxymoron, attention grabber, or over-ambitious wording. However, with increasing calls for cost recovery and private sector participation, the sector and the thinking are changing. While wastewater treatment has been primarily a 'social business model' with a strong economic justification and returns on investments through safeguarding public health and the environment, cost recovery is a significant advantage from the financial perspective, not only for private sector engagement, but also within the public sector where in low income countries overdue and delayed payments for repairs and salaries accelerate the breakdown of treatment infrastructure. Also regular household billing to cover the costs of conveyance, treatment, and disposal of wastewater or fecal sludge, as known from developed countries to finance their treatment systems, might not reach far in low-income countries where fees are low, and enter the same municipal cashbox which has to support all bottlenecks the municipality at large is facing. Effective billing and dedicated accounting systems, are seldom put into place. As a result, most facilities—especially high end-facilities, appear to be on a run-to-failure trajectory from their inception.

Shifting incentives for financing sanitation from "front-end users" to "back-end users" could build on demand for the products of sanitation (e.g., treated wastewater) to motivate a shared finance model and more robust operation and maintenance of complete sanitation systems. This requires a reuse-oriented planning approach to sanitation. In this approach, treatment is matching reuse needs and water reuse business models are seen as a component of the overall sanitation service chain which starts with the toilet and ideally feed parts of its reuse revenues back into the functioning of the overall chain.

The second target is to recover as much as possible the normal operational and maintenance cost of the treatment process. This can be very ambitious, but is not impossible as we see in case of energy recovery or the reclamation of potable water. The third target, i.e. to break even and to start making profit to recover capital costs, is seldom but also possible for example where:

- Treatment technology is low cost (like pond based systems)
- More than water is recovered allowing a more sophisticated value proposition
- The corresponding market for the recovered resources or their products is sufficiently large.

It is difficult to capture in one grand business typology the various forms of reuse, even if limited to irrigation (direct and indirect reuse, formal and informal, treated and untreated, etc.). However, there are options cutting across different forms of reuse based on the actors involved, and the purpose or the value proposition. A possible typology could be based, for example, on the ownership of the "business" and the motivation of the owner(s) between welfare maximization, cost recovery, and profit maximization. As resource recovery and reuse usually cut across sectors, decisions might not only depend on the supply end but also be driven by demand where resources are increasingly scarce. This change in motives sets the scene for new opportunities and innovative solutions for the reuse businesses. In this chapter, the typology used to describe the business models for wastewater use is differentiating between opportunities related to advanced water treatment and low-cost water treatment and largely based on the value proposition the reuse solution offers. Many governments and the private sector actors are beginning to realize the 'double value proposition' in water reuse: Without reuse, wastewater treatment has a significant economic value in terms of environmental safety and public health, but no financial value. Water, nutrient and energy reuse adds new value streams to the recovery value proposition.

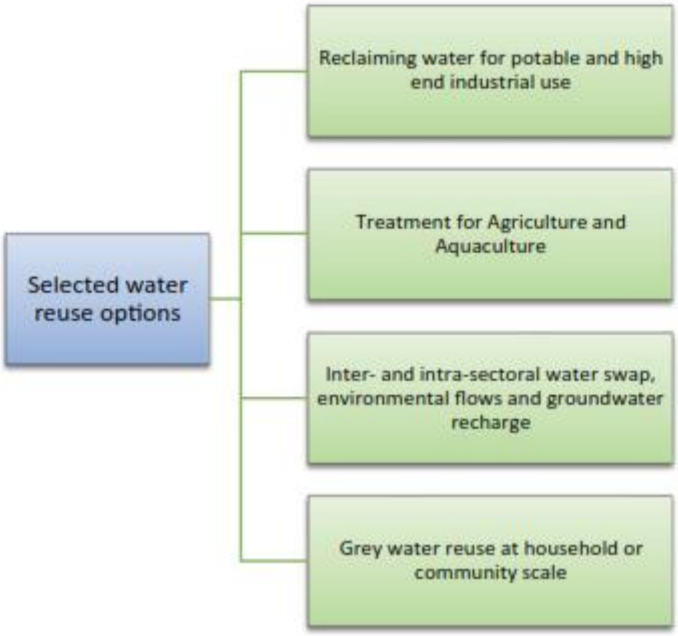


Fig 5.5 Selected value propositions related to the use of wastewater

There are many options for turning used water into an asset. A cost reduction model based on reduced fresh and wastewater treatment volumes could start with the decentralized support for grey water reuse at household level before any conventional treatment. Grey water generated through bathing and in kitchens can be locally captured, treated and reused at household, garden and community level. This reuse can be encouraged through subsidies for the installation of on-site treatment and reuse equipment, or through reduced drainage/wastewater fees and green building environmental rating tools for buildings benchmark and new building zoning laws, where not every cubic meter of grey water is needed to flush the sewer. Studies in Jordan showed that grey water reuse can also be financially attractive for the household with cost-benefit ratios of about 1.80 (over 5 years) and 2.58–2.75 over a 10 year period.

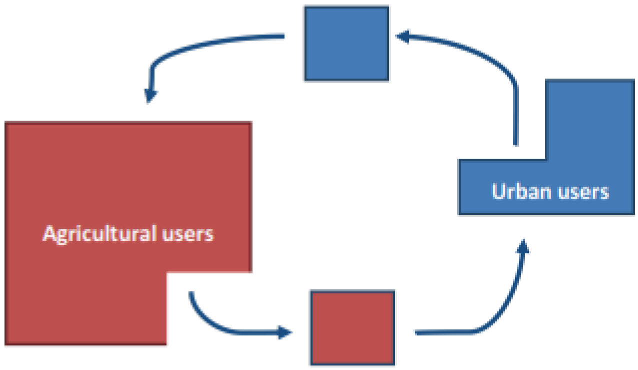
Where greywater and blackwater (from toilets) are captured within the same sewer system feeding into a decentralized or centralized treatment plant, the treated water can be reclaimed and made available for agricultural irrigation, groundwater recharge, aquaculture, as well as inter- and intra-sectoral water swaps with freshwater users and newly emerging models such as water hedging in futures markets depending on demand and required treatment standards.

Wastewater Reuse in Agriculture

Wastewater treatment and reuse is not new, and knowledge on this topic has evolved and advanced throughout human history. Reuse of untreated municipal wastewater has been practiced for many centuries with the objective of diverting human waste outside of urban settlements. Likewise, land application of domestic wastewater is an old and common practice, which has gone through different stages of development. This has led to better understanding of process and treatment technology and the eventual development of water quality standards.

Domestic wastewater was used for irrigation by prehistoric civilizations (e.g., Mesopotamian, Indus valley, and Minoan) since the Bronze Age (ca. 3200–1100 BC). Thereafter, wastewater was used for disposal, irrigation, and fertilization purposes by Hellenic civilizations and later by Romans in areas surrounding cities (e.g., Athens and Rome). In more recent history, the "sewage farms" (i.e., wastewater application to the land for disposal and agricultural use) were operated in Bunzlau (Silesia) in 1531 and in Edinburgh (Scotland) in 1650, where wastewater was used for beneficial crop production. In the following centuries in many rapidly growing cities of Europe and the United States, "sewage farms" were increasingly seen as a solution for the disposal of large volumes of the wastewater, some of which are still in operation today. Paris was a typical example with the first sewage farms established at Gennevilliers in 1872, eventually processing wastewater of the entire town. At the beginning of the last century, the sewage farms in France supplied with raw wastewater by the Colombes pumping station in Paris reached their maximum implementation, having been established in four different areas; in Gennevilliers (900 ha) and Achères (Achères plain, 1400 ha, Pierrelaye, 2010 ha and Triel, 950 ha). A large "sewage farm" also was established in Melbourne, Australia in 1897. The use of the land treatment systems continued into the twentieth century in central Europe, USA, and other locations all over the world, but not without causing serious public health concerns and negative environmental impacts. However, by the end of the first half of the current century, these systems were not easily accepted, due to drawbacks such as large area requirements, field operation problems, and the inability to achieve the higher hygiene criteria requirements required.

Against the backdrop of worsening water scarcity situations in many parts of the world, policy makers are looking for sustainable solutions to ensure safe and adequate water supplies for society. As part of a broad strategy encompassing inter-sectoral water transfers, water swaps have been suggested which aim at the provision of treated water for example to farmers for irrigation, in exchange for freshwater for domestic and industrial purposes . The business model can equally be applied to water swaps with other water-intensive users such as golf courses.



1. Urban wastewater is reclaimed for agricultural production.
2. Farmers will release a freshwater share for urban or environmental needs.
3. The swap will not change total water availability in the river basin context but more freshwater could get reallocated to higher valued uses.

Fig 5.6 Model for an inter-sectoral water swap

Water swaps will not change total water availability in the river basin context but more freshwater might be allocated to higher valued uses. This system is possible where water allocations are controlled and changeable and farmers get an incentive to agree to the trade. The incentive could be financed from the gains of the urban center through higher revenues based on a larger freshwater supply and treatment cost savings. If the farmers are upstream of the city, there will be costs for pumping the wastewater back to the farm areas. Distance will matter as distribution system costs can be the most significant component of costs for non-potable reuse systems, i.e. the cost of electricity to access and pump freshwater from long distance sources and then to pump the waste out of the city. If distances are short, water swaps could be a feasible mean of mitigating water scarcity problems with economic benefits both from the perspective of farmers and the society. However, villages in the downstream of cities, through scientific screening in required.

However, what looks in theory to be straight forward can be complicated in practice. This concerns the required institutional and incentive arrangements but also physical bottlenecks, like increased water salinity through (pond) treatment, making reclaimed water less suitable for farmers. Another challenge would be that in water scarce regions, where cities struggle to access water, also agricultural production. Is water limited. Providing farmers with an additional water source might result in expansion or intensification of irrigated farming, but not in a release of water.

Domestic Wastewater Reuse

Domestic water consumption makes up 8% of total global water use (UNWATER 2012). Particularly in developed countries, domestic water use is often many times larger than the WHO minimum recommended per capita consumption. Thus, household water consumption has a large potential to be reduced. Benefits of reducing domestic water consumption include lower water bills or less time spent collecting water, reduced pressure on local water resources, and increased availability of potable water available for appropriate purposes such as drinking, cooking, and hygiene.

One effective way of reducing water consumption is to reuse the wastewater produced at the household level. The reuse of wastewater presents an opportunity to not only save water and financial resources by reducing water consumption, but to simultaneously increase food production or create livelihood. In developing countries, optimising wastewater reuse can therefore be a significant window for development.

A critical aspect for wastewater reuse is that the quality of wastewater must be appropriate for its reuse. There are several different types of wastewater produced at the household level that have very different levels of contaminants (i.e. nutrients, pathogens) and reuse potential, including rainwater, greywater (all household wastewater except toilet flushing water), urine, blackwater, and faeces. Separating these streams of wastewater reduces the amount of wastewater contaminated by pathogens (i.e. blackwater, faeces, urine) by preventing it from coming into contact with less contaminated water (i.e. greywater, rainwater), thereby allowing greywater and rainwater to be used for a wider range of purposes.

By separating these waste streams at the source, it is possible to retain high volumes of relatively safe water (i.e. greywater, rainwater) that can be directly reused, whilst reducing the volume of wastewater (i.e. blackwater) that must be treated before reuse. Particularly in developing countries where water and wastewater systems are non-existent or incomplete, implementing source separation is key in developing sustainable systems that will benefit users over the long term. Depending on the contaminants present in wastewater and its future reuse, wastewater can either be directly reused, or treated and reused (recycled). Similarly, organic waste (such as kitchen waste or toilet waste) can also be reused at the household level to reduce the quantity of waste produced and to gain the benefits of nutrients or energy.

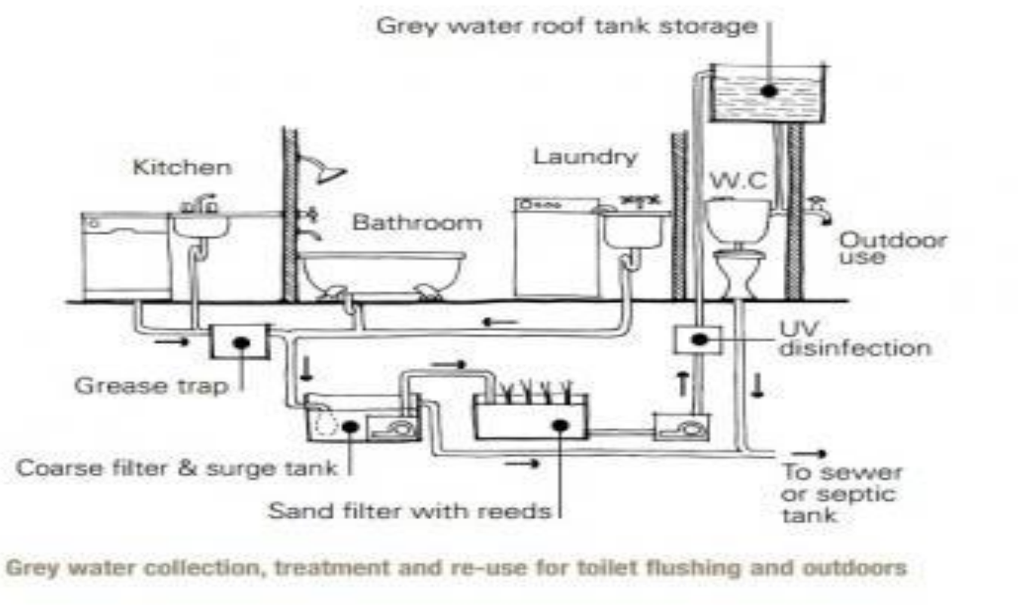


Fig 5.7 Household greywater reuse system

Water that is of a relatively high quality with few contaminants, such as rainwater or greywater, can be directly reused. Numerous technologies exist for household precipitation harvesting, while greywater can be collected by refitting pipes to divert wastewater from appliances like showers, washing machines, and sinks.

- Even though water for direct reuse may be relatively free of contaminants, the future reuse of rainwater and greywater must be appropriate for the level of contaminants present. Appropriate purposes for direct reuse can include
- Washing (cars, etc.)
- Flushing toilets (see toilet systems to learn more about different types of toilets and flushing systems)
- Gardening and food production can be done with greywater towers, vertical gardens, fertigation, drip-irrigation, and subsurface drip irrigation

Measures can be taken for optimising (reducing, reusing) wastewater or organic waste in almost any household. It may be more difficult to reuse greywater if significant changes must be made to wastewater collection, such as in areas where greywater collection must be modified, or if reusing wastewater is illegal. However, if it is permitted, reusing wastewater can greatly reduce the amount of potable water that is needed for a household. Particularly in areas where water delivery and wastewater collection is done manually, water reuse reduces the amount of drinking water that must be collected, reduces the time and effort spent collecting water, and increases the availability of potable water for appropriate purposes such as drinking, cooking, and personal hygiene.

Industrial Wastewater Reuse

Since the Second World War, rapid development has improved the standard of living and quality of life for millions of peoples the world over. This growth has come at the cost of a thirty-fold increase in the use of fossil fuels and a fifty-fold increase in industrial production over the past century. As a result, significant amounts of once freely available natural resources have been consumed by industry, leaving the earth depleted for future generations. Much of the waste produced from these activities is directly discharged into natural water bodies. In developed countries, industry is the biggest consumer of water and accounts for 50% to 80% of total demand. This is far more than the 10% to 30% in developing countries where agriculture is the largest consumer. However, industrial water use is certain to increase over the next decade. In many countries, the high rates of consumption in the last decade have exceeded capacity to replenish dwindling water sources and put excessive pressure on existing resources driving up the cost of raw water for industrial applications.

Discharge of wastewater into natural water bodies is also increasing costs for industries located downstream and this translates into higher production costs which are inevitably passed on to consumers. This discharge is also exceeding natural purification capacities and depleting dissolved oxygen below levels which can support aquatic life. Meanwhile, industries using groundwater have caused severe damage to aquifers and their recharge capacity resulting in lower groundwater levels each year. For countries located in coastal areas, seawater intrusion is also threatening to make groundwater unsuitable for direct use.

Public awareness and government application of effluent standards has already forced many industries to implement appropriate treatment technologies. Initially, industries adopted simple physio-chemical treatment systems, but rapid degradation of the environment has forced governments to implement more stringent regulations for wastewater effluent and these standards have led to more advanced biological and membrane technologies.

Reusing wastewater is an attractive economic alternative and helps conserve an essential commodity for future generations. Economic use also reduces the quantity of waste diverted to treatment facilities and further lowers treatment costs. Companies invest in wastewater treatment and reuse not just to comply with effluent standards but because product recycling and raw material recovery benefit a company’s image as well as the bottom line. In contrast to agriculture, only a small fraction of industrial water is actually consumed. Most is discharged as wastewater.

Industrial wastewater treatment has taken place in a series of development phases starting from direct discharge to recycling and reuse. This development has been slow considering the growing awareness of environmental degradation, public pressure, implementation of increasingly stringent standards, and industrial interest in waste recycling. The declining supply and higher cost of raw water is also forcing industry to implement recycling technologies. Many industries are now concentrating on methods to abate potable water intake and reduce discharge of polluted effluent. The move toward wastewater reuse is reflected in different "cleaner production" approaches such as internal wastewater recycling, reuse of treated industrial or municipal wastewater, and reuse of treated wastewater for other activities.

5.4 Recovery of Water

During most of the last and this century the trend has been for more mechanized wastewater treatment systems with almost every aspect of the various processes under the direct control of the operator. In the last twenty years. However, approaches that do not involve the same "concrete and steel" mentality have drawn more attention. Shortly after the enactment of the Clean Water Act (PL92-500) of 1972, alternate methods of wastewater treatment once again became recognized as valid means of achieving the required level of effluent quality. Initially, attention was centered on existing natural systems such as wetlands and coastal marshes, but more recently, constructed systems using aquatic plants have been investigated.

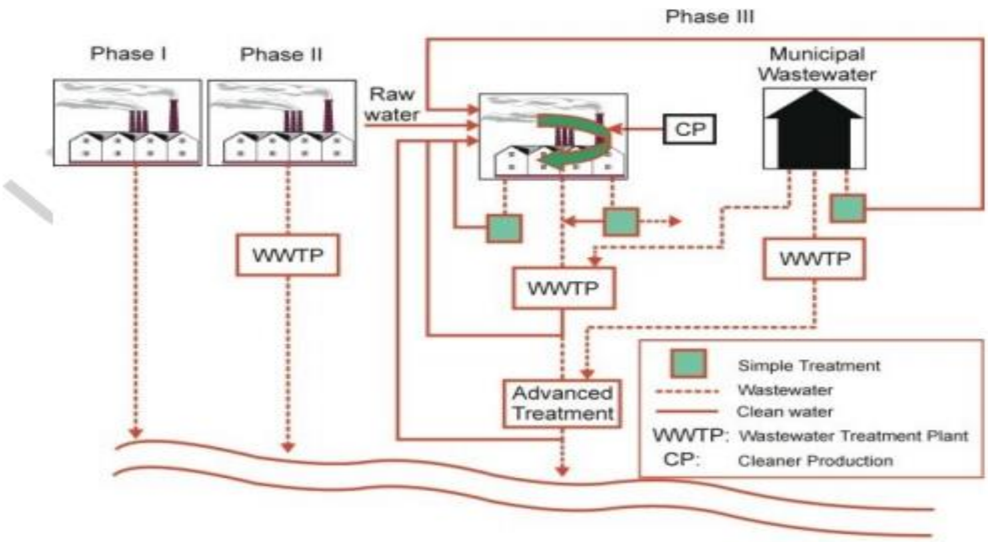


Fig 5.8 Development of industrial wastewater treatment and reuse

In the early days of sanitary engineering, natural treatment was the only method known. Initially, treatment was not even an objective, nor were the processes understood. Wastewaters were simply disposed of in the nearest river, lake or swamp if one was available. As the communities grew the carrying capacity of the receiving water was eventually exceeded and problems began to arise in terms of aesthetics, public health, environmental effects, or, more commonly, a combination of the three. The need for treatment prior to discharge was recognized at this point and primary treatment was developed to remove most of the larger solids and organic matter. Natural systems were more or less forgotten because they had not performed well under the required loads. As understanding of the environment, disease causing agents, and treatment processes increased the complexity of the treatment processes also increased to remove higher and higher percentages of the pathogens and contaminants of concern. The cost of treatment unfortunately increased as well and continues to do so even in the absence of further increases in treatment complexity. The Clean Water Act further aggravated the problem by requiring secondary treatment at many sites that had not previously used that level of treatment.

Natural treatment systems came back into consideration mostly as an attempt to find a more cost effective means of achieving the mandated treatment levels than was available with the existing mechanical or chemical processes. Natural treatment systems are not disposal practices nor are they random applications of waste and wastewater in various habitats. Natural treatment systems are engineered facilities which utilize the capabilities of plants, soils, and the associated microbial populations to degrade and immobilize wastewater contaminants.

The two main categories of natural treatment systems, are land treatment and aquatic treatment systems.

Land Treatment Systems

Land application of wastewater is perhaps the oldest method for disposal and treatment of wastewaters. Early systems were used in England as "Land Farms," which received untreated wastewater and night soil from nearby communities. Today, land application systems have included application to edible and nonedible crops, to rangelands, to forests and wood plantations, to recreational areas including parks and golf courses, and to disturbed lands such as mine spoil sites.

Land application of wastewater also plays a role in recharging ground-water and recycling fresh water. On the average, water that is used once and then discharged to the ocean would not return as rain on land for about 2,600 years. This fact has shed a spotlight on the wastewater reuse issue. Wastewater reuse in agriculture and other fields is not new; however, increasing environmental awareness has made the reuse of wastewater, even after careful treatment, a tainted prospect. This level of concern about reuse of wastewater is not unreasonable, given the checkered history of wastewater disposal throughout human development across the world. But as wastewater treatment technologies advance and quality of treated effluents steadily improves, the land application of treated wastewater from food and agriculture becomes a cost-effective alternative to discharging into the surface water, including oceans.

Land application of wastewaters incorporates organic and inorganic materials into the soil for recycle and reuse. The assimilative capacity of a soil is dependent on its characteristics and environmental conditions. The maximum capacity of a soil represents the maximum wastewater loading of the soil. This is true for raw wastewaters as well as treated wastewaters. Each application site will have a controlling parameter dependent on characteristics of the wastewater applied and characteristics of the soil, and most importantly, the environmental ramification. In most cases, permits are required for applying wastewater to the land.

The land application of wastewaters is not without risk of contamination of soil and groundwater beneath it. The challenge is to utilize the physico-chemical and biological properties of the soil as an acceptor for the waste-water streams without undue effect on the crops that are to be grown or to the ecosystem of which the land is a part, to the characteristics of the soil, and to the quality of the groundwater and the surface water. The wastewater and the soil to which the wastewater is applied should be managed as an integrated system to obtain the best outcome of the application.

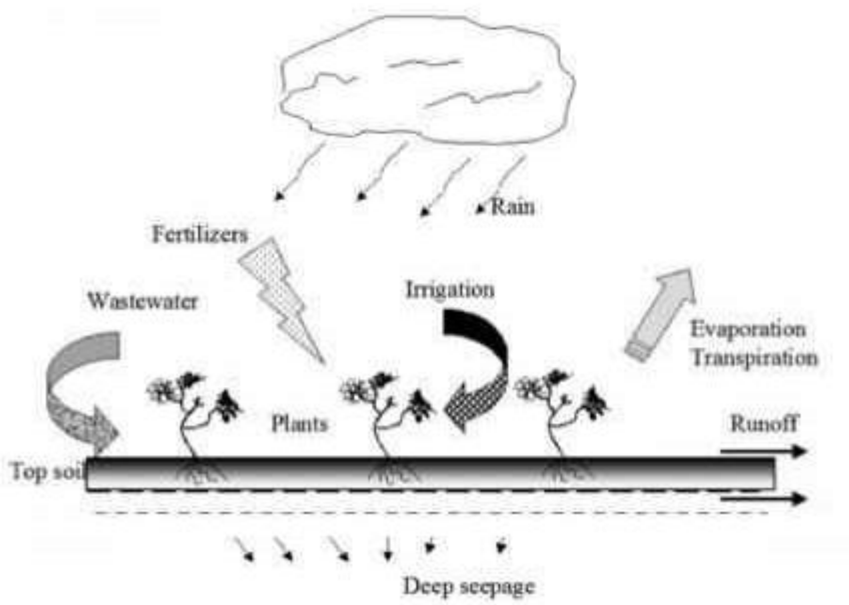


Fig 5.9 Illustration of land applications of wastewaters

Various designs of land application systems have been developed, including application of wastes to the soil-surface using slow rate, overland flow, and rapid infiltration land treatment systems, and to the subsurface using leaching fields and absorption beds. The suitability of a particular system depends on site characteristics, including soil properties, ground topography such as slope and relief, local hydrology, groundwater depth and quality, land use, climatic factors such as temperature, precipitation, evapotranspiration, wind, length of growing season, and expected waste loading rates, as well as consideration of possible social and economic.

Waste Water Treatment in Wetlands

The use of wetlands for wastewater treatment is not a new phenomenon but is one which is gathering increased momentum within the water industry due to the environmental benefits and the relatively low operations and maintenance requirements associated with these systems.

Research in 2010 reported that aquatic plants (macrophytes) were used in wastewater treatment experiments in Germany in the early 1950s. These manufactured or constructed wetlands have been developed in various forms across the globe with the common aim of harnessing nature's ability to clean wastewater through the physical, chemical, biological and microbial processes contained within 'Natural Wetlands'. This article offers a perspective on wastewater treatment in wetlands from an operations point of view.

Natural wetlands are areas where land is covered by water, either saltwater, freshwater or a mixture of both. Marshes and ponds, the edge of a lake or ocean, the delta at the mouth of a river or low-lying areas that frequently flood are all wetland areas. They contain plants and vegetation that thrive in the submerged or partially submerged conditions.

The plants act as an impediment to flow and are sustained by nutrients from the soils and the water. Natural wetlands have been described as the kidneys of the landscape because of their ability to assimilate and treat water lost from the landscape before it enters into receiving waterways.

Constructed wetlands are artificial wastewater treatment systems consisting of shallow vegetated ponds planted with aquatic plants with the purpose of treating wastewater by means of natural physical, chemical, biological and microbial processes. They are designed to control the flow direction, liquid retention time and water levels. After passing through the system the treated effluent is allowed to discharge safely into a receiving surface water or ground water.

There is a wide variety of different types of constructed wetlands in use throughout the world but the systems used in Ireland can be categorised into two broad areas

- Engineered Reedbed Systems; and
- Integrated Constructed Wetlands.

Engineered Reedbed Systems

Engineered Reedbed Systems are a functional element in a treatment process, with primary and/or secondary treatment process elements provided (depending on the particular treatment process at the plant) up front of the reedbed wetland pond or ponds, which can be surface flow and/or sub-surface flow, generally with a single plant species within a gravel media and lined with polyethylene barriers. A reed bed, or constructed wetland is an engineered structure – like a pond – normally rectangular in shape. It harnesses the natural ecological processes that break down organic matter in wastewater. They contain gravels that are usually planted with common river reeds (PhragmitesAustralis).

Contaminated liquid effluent is applied either at one end or across the entire surface (depending on the reed bed type), and collected from the other end by a series of drainage pipes or a weir outlet structure at the bottom. As the effluent passes through the gravels in the reed bed, it comes into contact with the bacteria growing in the oxygen rich atmosphere of the root system and on the surfaces of the gravels. This is the primary agent that breaks down and digests the sewage in the effluent.

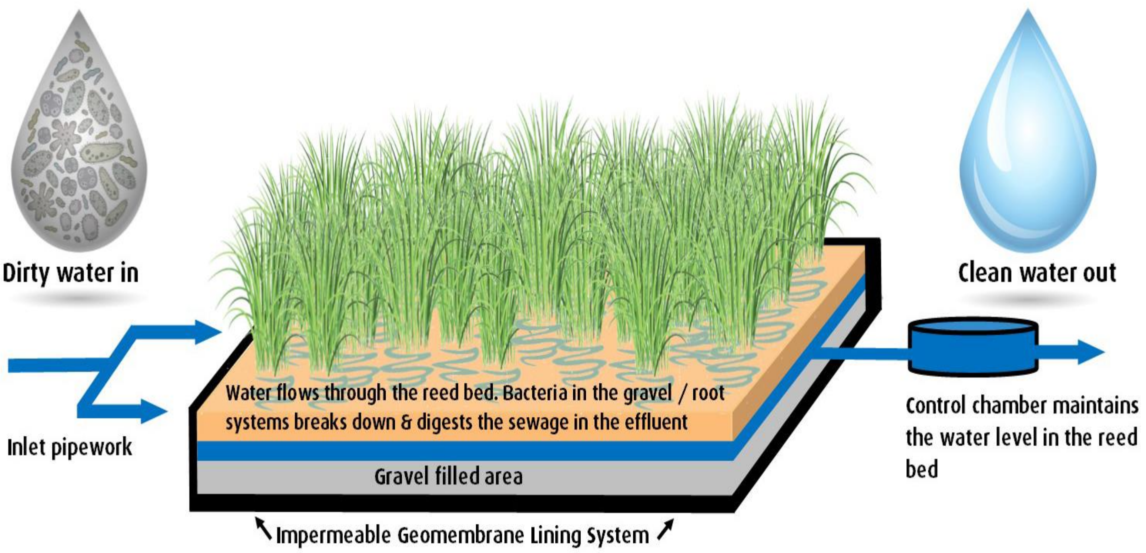


Fig 5.10 Reed Bed design

Reed beds are highly effective when properly designed and can be used in conjunction with ponds and wetlands to produce near river quality water. Vertical flow reed beds are more effective at nitrifying effluents: converting ammonia to nitrates and nitrites than most package sewage treatment plants.

Integrated Constructed Wetlands

Integrated Constructed Wetlands (ICWs) are a sustainable wastewater treatment system constructed with natural materials and designed to integrate into the landscape with the purpose of treating wastewater by using a series of ponds with a variety of wetland plants to clean the water before allowing it return safely to the environment.

These systems generally have a primary settlement tank or primary ponds followed by a series of vegetated wetland ponds. The Department of the Environment, Heritage & Local Government Integrated Constructed Wetlands Guidance Document for Farmyard Soiled Water & Domestic Wastewater Applications, published in 2010, explains that the ICW concept was developed to

- Integrate water flow and water quality management with landscape fit and biodiversity enhancement;
- Deliver enhanced treatment with emphasis on phosphorous removal;
- Provide greater system robustness and sustainability.

Wetlands are adaptable and versatile systems that can be utilised for primary, secondary and/or polishing processes for the treatment of wastewater effluent. These systems have gained recognition for providing a sustainable treatment option for small rural settlements and provide opportunities for enhancing existing wastewater treatment plants.

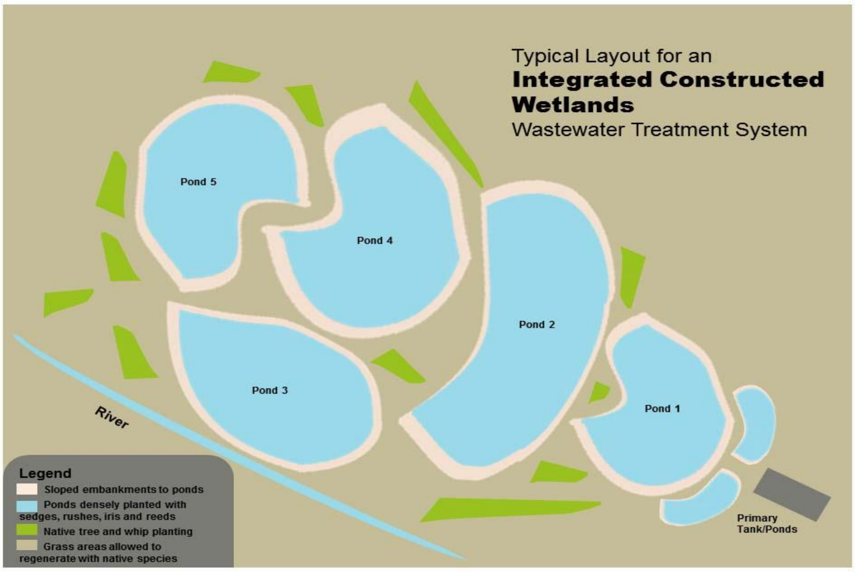


Fig 5.11 Integrated Constructed Wetlands

Benefits

The benefits of wastewater treatment in wetlands range from protecting and enhancing the environment, increasing biodiversity, facilitating carbon capture and storage, extended service life when compared with conventional treatment systems and provide a robust, sustainable and aesthetically pleasing wastewater treatment plant. But the key benefit of wastewater treatment in wetlands from an operations perspective is the low cost of operation of these systems, they offer real savings in terms of energy use, demand on operations staff time and resources as well as sludge production, handling and disposal – all significant considerations when faced with managing the provision of effective wastewater treatment services within challenging budgetary constraints.

5.5 Reuse of Plastic

Plastics are integral part of society and have varied application. Plastics are composed of a network of molecular monomers bound together to form macromolecules. There are increasing concerns due to non-degradability and generation of toxic gases on combustion during incineration. Due to fabrication of desired shape colour and specification convenient to customers there is increasing application in packaging, agriculture, automobiles and biomedical. They are indispensable to the modern generation due to development in information technology, intelligent and smart packaging system. Efforts are in progress for development of efficient and precise conversation of renewable raw materials into innovative polymeric product through recent technologies which are superior in terms of performance, environmental and cost perspectives. In rivers and at coastal regions the marine pollution is increasing at a faster rate due to indiscriminate disposal by the consumers. R&D studies are now centred for investigating whether consumption of plastic debris by marine organism translates into toxic exposures for people who consume seafood with particular relevance to plasticisers, stabilizers, heavy metals viz phthalates, BPA, lead cadmium, methyl mercury. Biological effects from pollution are linked with resulting economic effects and losses. A cornerstone of sustainable development is the establishment of affordable, effective and truly sustainable waste management practices in developing countries.

Plastic waste management is a critical issue. Over 300 million metric tons of plastics are produced in the world annually and about fifty percent of this volume is for disposal applications, product that are discarded within a year of their purchase. It is the boon and bane of our times. Although there are multiple uses, its waste and the resultant pollution clogs up our rivers, oceans, lands and adversely affects the biodiversity. We need to plan for disposal of new synthetic product, implants etc which have completed their shelf life. In future polymeric adhesives and implants are to be developed which address total joint replacement features for patients with varied complications and age. It should be robust, biocompatible with surface treatment options to allow for reduced friction and wear throughout the implant life. In a CPCB supported study it was found that the soil and ground water quality may be affected in dumpsite areas.

The International Organisation for standardization [ISO] Organisation for Economic Cooperation [OECD] and development, British specification [BS] Indian Standards [IS] need to be implemented for appropriate application and safe disposal. Globally steps are being taken for development of environmental friendly, innovative plastic items using the concept of green chemistry and also with safe disposal methods. Integrated waste management practices are to be encouraged, strengthened and supported with state of art scientific applications.

Waste Plastic to Fuel

In chemistry, plastics are large molecules, called polymers, composed of repeated segments, called monomers, with carbon backbones. A polymer is simply a very large molecule made up of many smaller units joined together, generally end to end, to create a long chain. The smallest building block of a polymer is called a monomer. Polymers are divided into two distinct groups: thermoplastics (moldable) and thermo sets (not). The word “plastics” generally applies to the synthetic products of chemistry. More than 15,000 tones of plastic waste are generated in India everyday, of which 6,000 tones remain uncollected and littered, the government today said. However, as per the CPCB report in 2014-15, 51.4 million tones of solid waste were generated in the country, of which 91 per cent was collected, and 27 per cent was treated and remaining 73 per cent disposed of at dump sites. "Central Pollution Control Board has estimated the generation of 15,342 tones of plastic waste in the country, out of which, 9,205 tones were reported to be recycled and leaving 6,137 tones uncollected and littered".

Liquid fuel within this compendium is defined as plastic-derived liquid hydrocarbons at a normal temperature and pressure. Only several types of thermoplastics undergo thermal decomposition to yield liquid hydrocarbons used as liquid fuel. PE, PP, and PS, are preferred for the feedstock of the production of liquid hydrocarbons. The addition of thermosetting plastics, wood, and paper to feedstock leads to the formation of carbonous substance. It lowers the rate and yields of liquid products.

Depending on the components of the waste plastic being used as feedstock for fuel production, the resulting liquid fuel may contain other contaminants such as amines, alcohols, waxy hydrocarbons and some inorganic substances. Contamination of nitrogen, sulfur and halogens gives flu gas pollution. Unexpected contamination and high water contents may lower the product yields and shorten the lifetime of a reactor for pyrolysis.

Liquid fuel users require petroleum substitutes such as gasoline, diesel fuel and heavy oil. In these fuels, various additives are often mixed with the liquid hydrocarbons to improve the burner or the engine performance. The fuel properties such as viscosity and ash content should conform to the specifications of the fuel user’s burners or engines. No additives would be needed for fuel used in a boiler. A JIS technical specification was proposed for pyrolytic oil generated from waste plastic for use as boiler and diesel generator fuel.

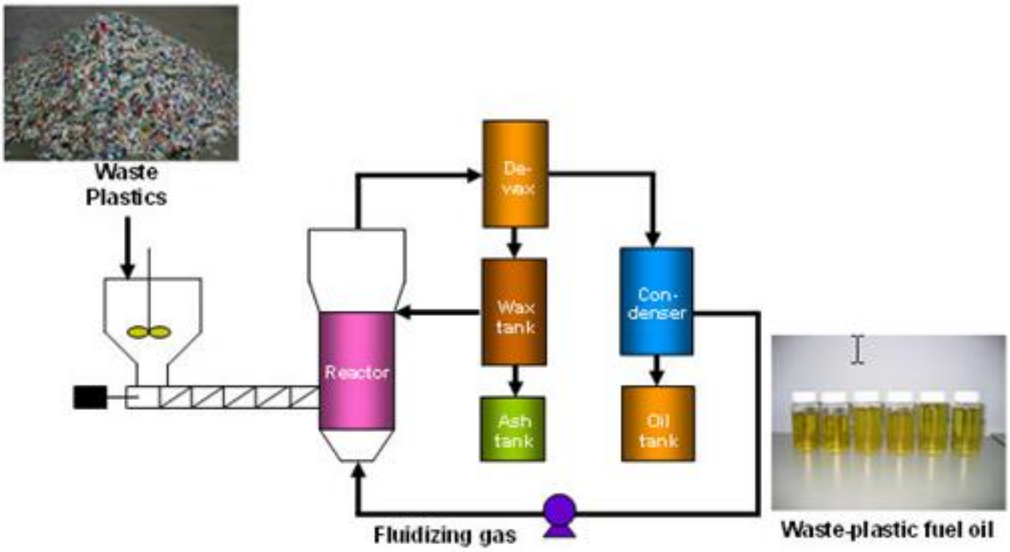


Fig 5.12 Pyrolysis of Plastic

The technology is used to dissolve these all type waste plastic is pyrolysis. The pyrolysis is the heating substance in the absence of oxygen. In this study 4300 Celsius temperature need. The all type of waste plastic is converting to fuel. It works like Petrol, diesel, kerosene and LPG. By implementing this concept can be reduced 80-90% of waste plastic and can be provide 60% oil for diesel vehicles. The fuel does not emit sulfur dioxide.(SO2). It increases machine efficiency. The 5% residue is obtained which is carbon block.

Use of Waste Plastics in Road Construction

Plastic roads are made entirely of plastic or of composites of plastic with other materials. Plastic roads are different from standard roads in the respect that standard roads are made from asphalt concrete, which consists of mineral aggregates and asphalt. Currently, there are no records of regular roads made purely of plastic. Plastic composite roads, however, have existed and demonstrate characteristics superior to regular asphalt concrete roads; specifically, they show better wear resistance. The implementation of plastics in roads also opens a new option for recycling post-consumer plastics. Australia, Indonesia, India, United States, The UK, and many other countries have used technology which can incorporate plastic waste into an asphalt mix.

Plastic waste can be used in hot mix to improve physical properties of bituminous aggregate mix by 'Dry Process' or 'Wet Process'. The technology incorporates the use of 'Plastone', a mixture of stone chips and waste plastic bags (thickness 40-70 µm) which is heated at 150-170 degree C during production, in laying roads, pavements and flooring purposes as an alternative to interlocking paver blocks. At this processing temperature, the plastic waste is heated enough to act as an adhesive in binding stone chips and not generating any toxic gases. The aggregate becomes water proof after getting coated with molten plastic. This step is followed by the addition of hot plastic-aggregate mix to hot bitumen while maintaining the process temperature. This approach is known as 'Dry Process'. The 'Wet Process' involves mixing of plastic to hot bitumen followed by mixing with hot aggregate. Both the processes lead to the formation of plastic modified bituminous aggregate mix with enhanced properties imparting strength, stability and durability to the roads.

Plastic-tar roads have benefits over conventional roads such as the overall reduction in bitumen consumption by 8%, enhanced load carrying strength, reduced wear and tear, prevents release of 3 tonnes of CO_2 (through disposal by burning) into the atmosphere, increased road strength, excellent resistance to water and water stagnation, no stripping and potholes formation, enhanced binding, reduced rutting and ravelling, improved soundness property, negligible maintenance cost of the road, no leaching of plastics and no effect of UV radiation.

Summary Points

- Resource recovery goes further than just the management of waste. Improvements to administration, source separation and collection, reuse and recycling are important.
- To achieve multiple sustainable development goals through the implementation of sanitation technologies that have potential to recover beneficial resources.
- Waste to energy generates clean, reliable energy from a renewable fuel source, thus reducing dependence on fossil fuels.
- Nutrient recovery is trending in the wastewater industry and bringing to light varied nutrients from diversified production and consumption sectors.
- Wastewater reuse applications instead of using freshwater supplies can be a water-saving strategy. When used water is eventually discharged back into natural water sources, it can still have benefits to ecosystems, improving streamflow, nourishing plant life and recharging aquifers, as part of the natural water cycle.
- Alternative Plastic Reuse strategies like energy recovery and recycling are essential for sustainable management of mounding plastic pollution.

To do Activities

1. Identify the current waste treatment and reuse practices in your municipality. Present the scope for water reuse and resource recovery based on the types of contamination.
2. Identify the current waste disposal practices of biodegradable and non-biodegradable wastes in a residential colony, and present the scope for decentralized resource recovery and reuse action plan.

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Dr. W. G. Prasanna Kumar, PhD in Education with basic degree in Social Work and Master's Degrees in Sociology, Public Administration and Political Science has professional education in Environmental Economics, Public Relations, Communication and Training and Development. Presently Chairman, Mahatma Gandhi National Council of Rural Education (MGNCRE) under the Ministry of Human Resource Development, in Government of India strives to promote resilient rural India through Higher Education interventions. The national initiative of reviving Mahatma Gandhi's ideas of Nai Talim, spearheaded by Dr. W G Prasanna Kumar, has met unprecedented success at both national and state levels. The primary objective of this initiative is to promote Gandhiji's ideas on Experiential Learning, NaiTalim, Work Education and Community Engagement, and mainstreaming them in School Education and Teacher Education Curriculum & Pedagogy. As Professor and Head Centre for Climate Education and Disaster Management in Dr MCR HRD Institute, conducted several capacity building and action research programmes in climate education, disaster management and crowd management. He has handled many regional, national and international environmental education programmes and events including UN CoP11 to Convention on Biological Diversity and Media Information Management on Environmental Issues.

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