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Centre for Regional Development

Country Chapter
State of the 3Rs in Asia and the Pacific

The Republic of India

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Author:
Prof. Dr. Sadhan Kumar Ghosh
Professor, Department of Mechanical Engineering, Jadavpur University, Kolkata, India
President, International Society of Waste Management, Air and Water (ISWMAW)

Member of Drafting Committee of State of the 3Rs in Asia and the Pacific

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Disclaimer

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United Nations Centre for Regional Development (UNCRD)

Author
Prof. Dr. Sadhan Kumar Ghosh
Professor, Department of Mechanical Engineering, Jadavpur University, Kolkata, India
President, International Society of Waste Management, Air and Water (ISWMAW)

Editor

Dr. Chen Liu	IGES
Dr. Yasuhiko Hotta	IGES
Mr. Yoshiaki Totoki	IGES

Editorial Support

Ms. Emma Fushimi	IGES
Ms. Miki Inoue	IGES

Coordinated by:
The Secretariat of the Regional 3R Forum in Asia and the Pacific,
United Nations Centre for Regional Development (UNCRD)
Nagono 1-47-1, Nakamura-ku, Nagoya 450-0001, JAPAN
Tel: (+81-52) 561-9377
Fax: (+81-52) 561-9375
E-mail: rep@uncrd.or.jp

Institute for Global Environmental Strategies (IGES)
2108-11, Kamiyamaguchi, Hayama, Kanagawa, 240-0115, Japan
Tel: +81-46-855-3700 Fax: +81-46-855-3709
E-mail: iges@iges.or.jp
URL: http://www.iges.or.jp

ABREVIATIONS

3Rs	Reduce, Reuse, Recycle
5Rs	Reduce, Reuse, Recover, Recycle and Remanufacture
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BM	Biomethanation
C & DW	Construction & Demolition Waste
CBWTF	Common Bio-medical Waste Treatment Facility
CPCB	Central Pollution Control Board
EEE	Electrical and Electronic Equipment
ELV	End-of-Life Vehicle
EPR	Extended Producer Responsibility
GHG	Greenhouse gases
GPCD	Grams Per Capita Per Day
HW	Hazardous Waste
IGBC	Indian Green Building Council
IWP	Integrated Waste Management Plan
JNNURM	Jawahar Nehru National Urban Renewal Mission
MNRE	Ministry of New and Renewable Energy
MoEF&CC	Ministry of Environment, Forestry & Climate Change
MoUD	Ministry of Urban Development
MRF	Material Recovery Facility
MSME	Micro, Small and Medium Enterprises
MSW	Municipal Solid Waste
NGO	Non Governmental Organization
OEM	Original Equipment Manufacturer
RDF	Refused Derived Fuel
SBM	Swachh Bharat Mission
SCN	Supply Chain Network
SDG	Sustainable Development Goal
SPCB	State Pollution Control Board
TPD	Tonnes Per Day
WEEE	Waste Electrical and Electronic Equipment
ZED	Zero Defect & Zero Effect

CONTENTS

A: INTRODUCTION

The popular concept of waste reduction, reuse and recycle, often referred to as “3R”, is particularly applicable in the context of sustainable production and consumption. It calls for an overall reduction in resources and energy used, increase in the ratio of recyclable materials and further reusing of wastes. The 3Rs (Reduce, Re-use, Recycle) form part of the waste hierarchy and encourages the prioritization of waste reduction ahead of the re-use and recycling of materials, to the extent that this is economically feasible and socially acceptable. Source reduction is generally perceived as highest rung on this ladder with the greatest potential for avoiding energy and raw material consumption as well as waste generation. State of the 3Rs in Asia and the Pacific is a synthesis and status report that assesses the 3R policy implementation in the region based on country reports to Regional 3R Forum in Asia and Pacific. It aims to contribute to Sustainable Development Goals (SDGs) process by improved decision making towards effective implementation of 3R and environmentally sound waste management at local and national level, including promotion of 3R as an economic industry, by improving data, information, and indicators availability in all waste sectors (municipal, industrial, hazardous, WEEE, agricultural and biological, etc.) for achieving a low carbon and resource efficient region. This paper is the status report that assess the 3R policy implementation in Indian context.

B: WASTE DEFINITION

In India the Municipal Solid Wastes (Management and Handling) Rules, 2000 were implemented since the year 2000, while all the rules pertaining to the waste management have been revised in the year 2016 based on the learning from the implementation of the then existing rules and the demand of the present situation all over the world. Definition and categorisation of wastes in India is done by the Ministry of Environment, Forests and Climate Change (MoEF&CC) through the different legislations, related to waste management notified as Rules under the Environmental Protection Act (Bernard Galea 2010). These waste Categories and the definitions of different categories have evolved over the period of time with amendments and revisions in these notifications and the current definition and category as per the Solid Waste Management Rules 2016 in India are summarized in Table B-1. The regulated categories of wastes in India are, a) solid waste, b) hazardous waste, c) biomedical waste, d) electronic waste, e) construction and demolition waste, f) plastic wastes and g) lead acid batteries. These Rules define the roles and responsibilities of stakeholders, e.g., waste generators, operators of waste management facilities as well as Central and State implementing and regulatory agencies.

Table B-1 Waste Category and Definition as per Indian Legislations

Waste Category	Definition	Reference Legislation
Waste	Materials that are not products or by-products, for which the generator has no further use for the purposes of production, transformation or consumption. (i) waste includes the materials that may be generated during, the extraction of raw materials, the processing of raw materials into intermediates and final products, the consumption of final products, and through other human activities and excludes residuals recycled or reused at the place of generation; and (ii) by-product means a material that is not intended to be produced but gets produced in the production process of intended product and is used as such.	Solid Waste Management Rules, 2016 (MoEF&CC, 2016 a)
Solid Wastes	Solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other non residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio-medical waste and e-waste, battery waste, radio-active waste generated in the area under the local authorities.	Solid Waste Management Rules, 2016 (MoEF&CC, 2016 a)
Hazardous Wastes	Any waste which by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances, and shall include waste specified under column Schedule I, Schedule II and Schedule III of the Rules.	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. (MoEF&CC, 2016 b)

Waste Category	Definition	Reference Legislation
Biomedical Wastes	Any waste generated during the diagnosis, treatment or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps.	Bio-Medical Waste Management Rules, 2016 (MoEF&CC, 2016 c)
Electronic Wastes	Electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes.	E-Waste(Management) Rules, 2016 (MoEF&CC, 2016 d)
Demolition and construction waste	Waste comprising of building materials, debris and rubble resulting from construction, re-modelling, repair and demolition of any civil structure	Construction and Demolition Waste Management Rules, 2016 (MoEF&CC, 2016 e)
Plastic Wastes	Any plastic discarded after use or after their intended use is over	Plastic Waste Management Rules, (MoEF&CC, 2016 f)
Battery Wastes	Used Lead Acid batteries after their intended use is over	Batteries (Management and Handling) Rules, 20011 (MoEF,2011)

The Solid Waste Management Rules, 2016 has further classified the solid wastes into the different categories which includes, biodegradable waste, dry Waste, non-biodegradable waste, combustible waste, domestic hazardous waste, residual solid waste, inerts and sanitary waste which are appended in Table B-2.

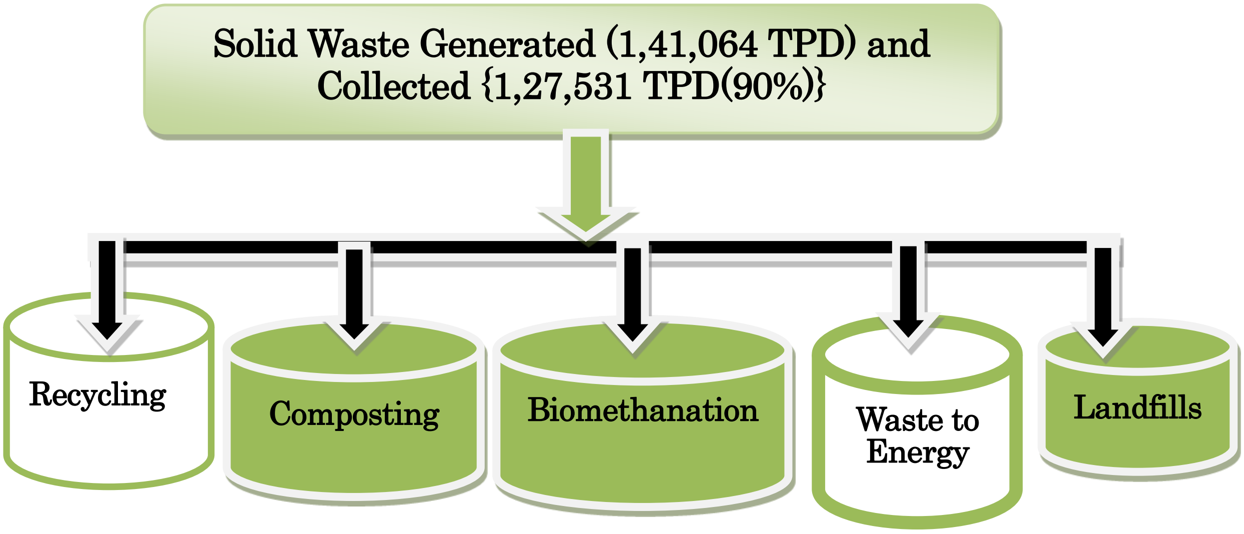
Though most of the wastes categories including many emerging wastes are regulated in India, there is no specific regulation pertaining to agricultural wastes, non-hazardous industrial wastes and end of life vehicles. The recent revisions in the waste related legislations have attempted to address the gaps identified in the performance audit report on management of waste in India (CAG, 2008) that emphasized on the waste management hierarchy. Most of the rules have envisaged that the management of wastes shall follow the hierarchy of waste as specified in the Solid Waste Management Rules, 2016, the priority order in which the solid waste should be managed by giving emphasis to prevention, reduction, reuse, recycling, recovery and disposal, with prevention being the most preferred option and the disposal at the landfill being the least. This rules also put emphasis on co-processing of non-biodegradable and non-recyclable solid waste having calorific value exceeding 1500kcal as raw material or as a source of energy or both to replace or supplement the natural mineral resources and fossil fuels in industrial processes. Urgent attention and action are also expected regarding assessment of the quantum of waste being generated and its impact on environment and health, enforcement of compliance to rules and monitoring to check non-compliance and provision of funding and manpower for the implementation of rules on waste management.

Table B-2 Solid Waste Category as per Solid Waste Management Rules, 2016 in India

Solid Waste Category	Definition
Biodegradable waste	Any organic material that can be degraded by micro-organisms into simpler stable compounds.
Dry Waste	Waste other than bio-degradable waste and inert street sweepings and includes recyclable and non-recyclable waste, combustible waste and sanitary napkin and diapers, etc;
Non-biodegradable Waste	Any waste that cannot be degraded by micro-organisms into simpler stable compounds;
Combustible waste	Non-biodegradable, non-recyclable, non-reusable, non-hazardous solid waste having minimum calorific value exceeding 1500 kcal/kg and excluding chlorinated materials like plastic, wood pulp, etc;
Domestic hazardous waste	Waste contaminated with hazardous chemicals or infectious waste such as discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge, etc., generated at the household level;
Residual Solid Waste	Includes the waste and rejects from the solid waste processing facilities which are not suitable for recycling or further processing;
Inerts	Wastes which are not bio-degradable, recyclable or combustible and includes non-recyclable fraction of construction and demolition waste, street sweeping or dust and silt removed from the surface drains.
Sanitary waste	Wastes comprising of used diapers, sanitary towels or napkins, tampons, condoms, incontinence sheets and any other similar waste.

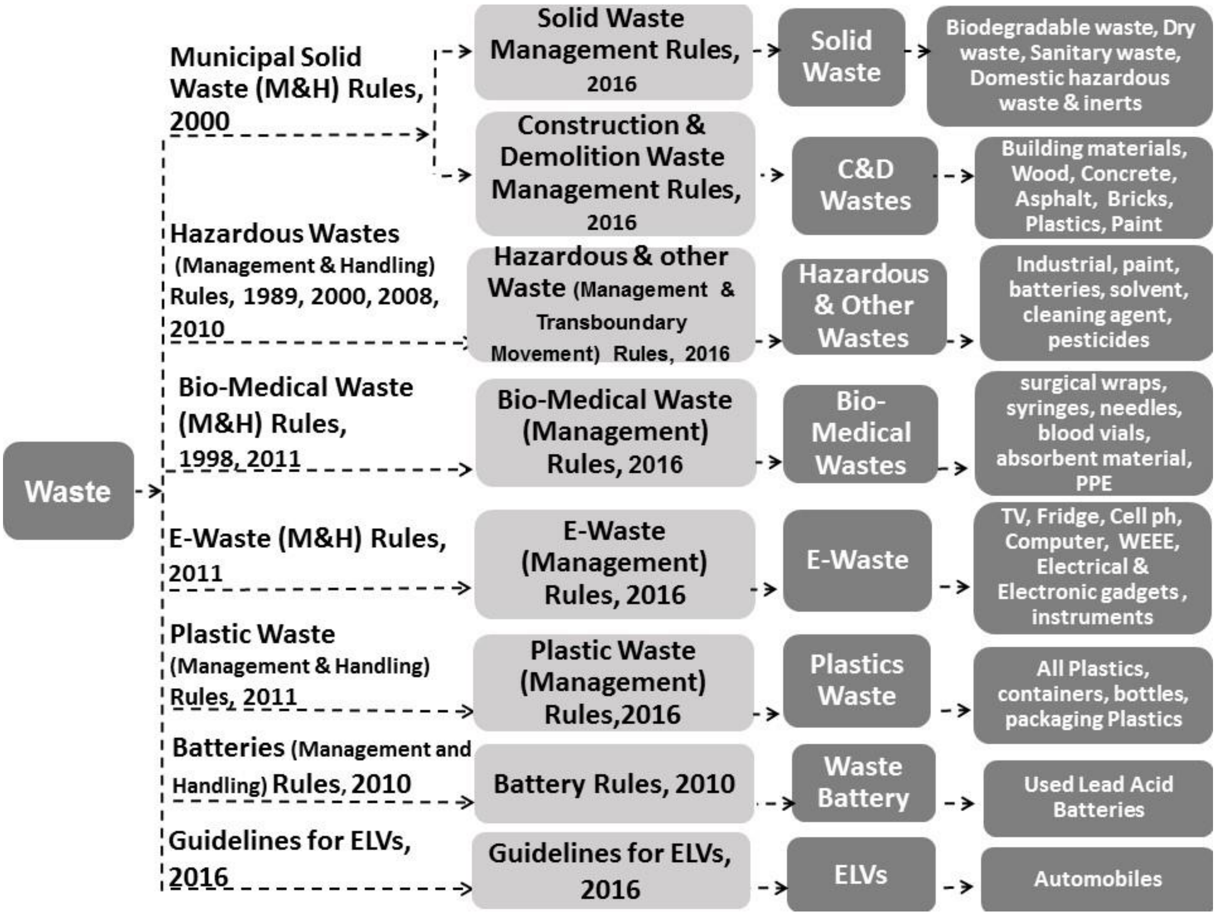
Source: SWM Rules 2016 and prepared by author

The overall flow of the solid waste generated, 1,41,046 tonnes per day based on the available data for 2013-2014 in the country with CPCB (Source: CPCB Bulletin Vol.- I, July 2016, Government of India) is given in Figure B-1. Waste Management categories and respective legislations in India are shown in Figure B-1.



Source: CPCB Bulletin Vol.- I, July 2016, Government of India

Figure B-1 Overall flow of the solid waste in India



Source: Prepared by author

Figure B-2 Waste Management categories and respective legislations in India

C: COUNTRY SITUATION

India with an area of 3.287 million sq. km have twenty nine states and seven union territories shown in Figure C-1 with the population increased from 342 millions in 1947 to 1210 million in 2011, of which 31% live in cities. The number of towns has increased from 5,161 in 2001 to 7,935 in 2011 (Census 2011). It is further projected that by 2050 half of India's population will live in cities. India with its vast areas of land and water has unity with diversity. Besides Hindi, the following languages (arranged in descending order as regards numbers of speakers) are each spoken by more than25 million Indians - Bengali, Telugu, Marathi, Tamil, Urdu, Gujarati, Kannada, Malayalam, Odia and Punjabi. India has 22 official languages written in 13 different scripts, with over720 dialects. According to Census of India in 2011, the total number of mother tongues spoken in India is 1652. However, only around 150 languages have a sizable speaking population. The Indian census of 1961 recognised 1,652 different languages in India (including languages not native to the sub-continent). In most of the states in India English is taught from the very childhood. The official Indian languages are Hindi (with approximately 420 million speakers) and English, which is also widely spoken. Waste Management in this vast land with a wider diversity is a challenge.

Source: www.mapsofindia.com

Figure C-1 India map showing all the states, union territories, their capital & the central capital at Delhi

Solid waste management in India is becoming better day by day, with the new and revised legislation of waste management in the year 2016, new schemes for cleanliness and waste management, namely Swachh Bharat Mission, AMRUT, Smart Cities, JNNURM etc. with the challenges of rapid urbanization, population growth and unplanned development in many cities. Emphasis on technology and PPP mode are given to enhance resource recovery and deriving energy and nutrients. The thrust in waste management in new legislation is to minimize the quantum of waste by adopting the "Concept of 5-R"– Reduce, Reuse, Recover, Recycle and Remanufacture and through integrated waste Management. The ultimate objective is zero waste to landfills with the core objectives of reduction in contamination to soil, water and air, minimization of adverse impacts on environment and health, increasing the level of resource recovery and recycling to reduce the Greenhouse Gas emissions.

With being the signatory to UN Convention on Environment, 1972 and Constitutional provisions, legislations and administrative directions to protect the Environment, Indian Government has shown its seriousness about the environment. Subsequently the government of India instituted the ministry of Forest and Environment in the central and all the state governments. The Ministry of Environment, Forests and Climate Change [formerly Ministry of Environment and Forests, (MoEF)] is responsible for planning, promoting, coordinating, and overseeing the implementation of environmental and forestry programmes in the country. The Central Pollution Control Board(CPCB) of India is a statutory organisation under the Ministry of Environment, Forest and Climate Change (MoEF&CC) established in 1974 by a special act of the Parliament entrusted with the powers and functions under different acts and to conduct environmental assessments and research and overseeing the pollution control boards in different states and union territories. MoEF&CC and CPCB are the nodal agencies of the Government of India for the rules pertaining to the waste management.

After the 1972, Indian Government bring major changes in environmental law, then it move from protection of environment through general law to specific law regarding environment. The UN Conference on Human Environment and Development held at Stockholm and 'Stockholm Declaration on the Human Environment' 1972 has the significant impact on India Environment Law. It is considered as magnacarta of Environmental law and it has same parallel significance as Universal Declaration on the Human Right, 1948. After the Stockholm Conference, 1972, Government of India brought the 42nd amendment in the Constitution and incorporated Article 48A and Article 51A (g). Article 48A comes under the part IV 'Directive Principle of State Policy', and under this Article the states are under the 'active obligation' that it shall endeavour to protect and impose the environment. Whereas Article 51A (g) states the citizen has the duty to protect and improve the environment. Article 51A (g) is not law and, a fortiori, not supreme law.

The State's responsibility with regard to environmental protection has been laid down under Article 48-A of the Constitution of India. The constitution of India provides a broad framework for environmental protection, which reads as follows: "*The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country*". Environmental protection is a fundamental duty of every citizen of this country under Article 51-A(g) of the

Constitution which reads as follows: "*It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures*." Article 21 of the Constitution is a fundamental right which reads as follows: "*No person shall be deprived of his life or personal liberty except according to procedure established by law*." Article 48-A of the Constitution comes under Directive Principles of State Policy and Article 51 A (g) of the Constitution comes under Fundamental Duties. The State's responsibility with regard to raising the level of nutrition and the standard of living and to improve public health has been laid down under Article 47 of the Constitution which reads as follows: "*The State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and, in particular, the State shall endeavour to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health*." The 42nd amendment to the Constitution was brought about in the year 1974 makes it the responsibility of the State Government to protect and improve the environment and to safeguard the forests and wildlife of the country. The latter, under Fundamental Duties, makes it the fundamental duty of every citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures. India put importance always to protect environment.

In recent past government of India has put emphasis on waste management introducing various dedicated schemes, namely, Swacchha Bharat Mission (SBM) introduced in October 2014, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) introduced in June 2015, Smart City Project in June 2015 and Jawaharlal Nehru National Urban Renewal Mission (JNNURM) scheme was launched in the year 2005 by the Government of India under Ministry of Urban Development. These provisions form the basis for the environmental governance for the protection of environment in India, including waste management.

In order to achieve a sustainable development path that simultaneously advances economic and environmental objectives, the government of India has launched the National Action Plan for Climate Change (NAPCC) with Eight National Missions. Recognizing that climate change is a global challenge, India engaged actively in multilateral negotiations in the UNFCCC the National Action Plan hinges on the development and use of new technologies. The implementation of the Plan would be through appropriate institutional mechanisms suited for effective delivery of each individual Mission's objectives and include public private partnerships and civil society action. The focus will be on promoting the understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation.

Following eight National Missions form the core of the National Action Plan (NAP), representing multi-pronged long term and integrated strategies for achieving key goals in the context to climate change. While several of these parts of concurrent actions, they may need a change in direction, enhancement of scope and effectiveness and accelerated implementation of time-bound plans.

- National Solar Mission - By 2022, India is expected to generate 175 GW of power via renewable sources, out of which 100 GW will be from solar energy.
- National Mission for Enhanced Energy Efficiency

- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a Green India
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for climate change

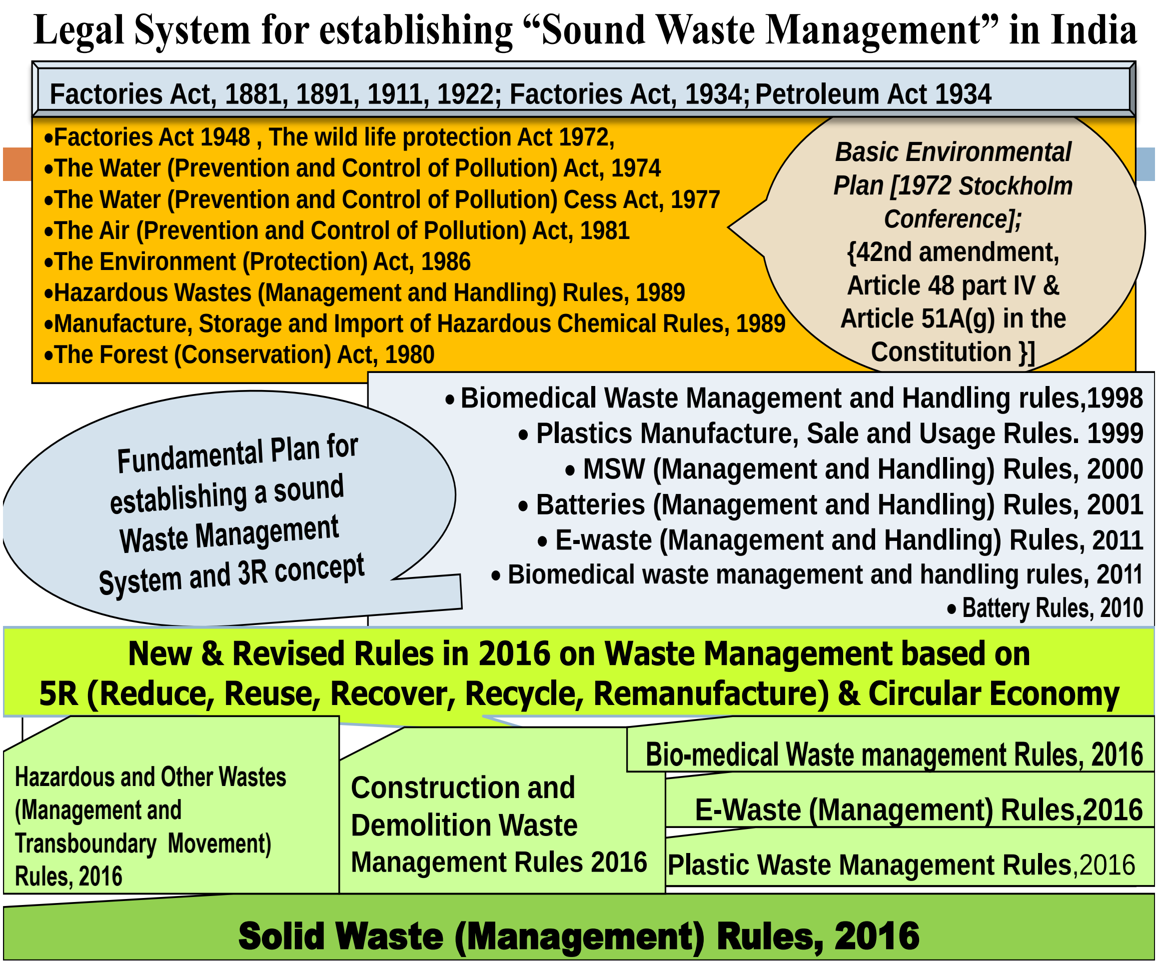
Bureau of Indian Standards (BIS) is involved in preparing the Indian standard "Municipal solid waste management – segregation, collection & utilization at household for recovery and recycling", Doc No. CHD 33(2259) C, BIS, India.

I. Legislation in India

In India the first legislation indirectly addressing the environmental aspects was the Factories Act 1881 subsequently amended in 1891, 1911, 1922 and 1934. In the independent India after August 15, 1947, the Factories Act 1948 was enacted that was amended in 1958 and 1977. Stockholm Conference, 1972 and the 42ndamendment of the constitution of India, have the impact on the environment related laws in India. After 1972, India enacted the Water Act 1974, Air Act 1981, Environment Protection Act, 1986, various policies and notification. The Bhopal gas leak incidence in 1984 has a great bearing in the enactment of several environmental legislations in India in subsequent days. The Environment Protection Act 1986 aims to establish a sufficient protection system for the environment. It gives the power to the central government to regulate all forms of waste and to tackle specific problems that may present themselves in different regions of India. The National Environmental Policy (MoEF, 2006) lay emphasis on adoption of clean technology, encourage reuse and recycling, strengthening of informal sector and establish system for collection and recycling of materials along with environmentally sound waste disposal. The "National Conservation Strategy and Policy Statement on Environment and Development" declares strategies for action in various spheres such as agriculture, forestry, industrial development, mining and tourism. The Policy Statement for Abatement of Pollution declared the objective of the government to integrate environmental considerations into decision making at all levels. To achieve this goal, the statement adopts fundamental guiding principles, namely: a) Prevention of pollution at source; b) Adoption of the best available technology; c) Polluter pays principles; and d) Public participation in decision-making. The National Environment Policy is now guiding action in regulatory reforms, programmes and projects for environmental conservation and review and enactment of legislation by agencies of the Central, State, and Local Governments. The policy also seeks to stimulate partnerships of different stakeholders, i.e. public agencies, local communities, academic and scientific institutions, the investment community, and international development partners, in harnessing their respective resources and strengths for environmental management.

Major initiatives, policies and activities on the 3Rs in India include Charter on Corporate responsibility for Environmental Protection, Waste Minimisation Circles, Comprehensive Environmental Pollution Index and Eco Labelling scheme and the requirements for Environmental audits (Manju Raina, 2010).The National Environment Policy seeks to extend the coverage and builds on *National Forest Policy (1988),National Conservation Strategy and Policy Statement on*

Environment and Development (1992),Policy Statement on Abatement of Pollution (1992), National Agriculture Policy (2000), National Population Policy, (2000) and National Water Policy, 2002. Figure C-2 shows the Evolution of environmental legislation in India with the driving force and its approach from 1881 till 2016 and Table C-1 shows the list of Environmental Legislation in India since the year 1934.



Source: S. K. Ghosh, 2016, 7th 3R Forum, UNCRD

Figure C-2 Evolution of environmental legislation in India and its approach

Table C-1 Environmental Legislation in India

Year	Environmental Legislations
1934	Petroleum Act,
1972	The wild life protection act,
1974	Water (Prevention & Control of Pollution Act) Amendments, 1988
1975	The Water (Prevention & Control of Pollution) Rules
1977	The Water (Prevention & Control of Pollution) Cess Act
1978	The Water (Prevention & Control of Pollution) Cess Rules
1980	The forest Conservation act, as amended in 1988
1981	The Air (Prevention & Control of Pollution) Act, Amendments, 1987
1982/ 1983	The Air (Prevention & Control of Pollution) Rules
1986	The Environment (Protection) Act, Amendments (1989, 1990, 1993, 1996, 1997, 1998, 1999, 2000, 2001)
1986	The Environmental (Protection) Rules
1992	E (P) Act Notification – "Environment Statement"
1994	E (P) Act Notification – "Environmental Clearance"
1997	Amendments in the Environment Clearance, Notification – "Public Hearing" made mandatory
1989	The Hazardous Wastes (Management and Handling) Rules, Amendments, 2000, Draft Amendments 2002
1989	Manufacture, Storage and Import of Hazardous Chemical Rules, Amendments,1994, 2000
1991	The Public Liability Insurance Act/Rules, 1992
1995	The National Environment Tribunal Act
1997	Prohibition on the Handling of Azo dyes
1997	The National Environment Appellate Authority Act
1998	The Bio-Medical Waste (M&H), Rules
1999	Notification for making 100% Utilization of Fly-ash made mandatory
2000	Municipal Solid Waste (M&H) Rules
2000	Ozone Depleting Substance (R&C) Rules
1999	Regulation on recycling of Waste Oil and Non-ferrous scrape
2000	Noise Pollution (Regulations and Control)
2001	Batteries (M&H) Rules
2001	The Energy Conservation Act.
2003	The Electricity Act,
2008	E-waste (management & handling) Rules, (Draft Rule)
2010	Batteries (M&H) Rules
2011	E-waste (Management and Handling) Rules, Biomedical Waste (Management And Handling) Rules, Plastics Waste Management Rules
2016	Solid Waste (Management) Rules Hazardous and Other Wastes (Management and Transboundary Movement) Rules Bio-medical Waste management Rules Construction and Demolition Waste Management Rules E-Waste (Management) Rules Plastics Waste Management Rules

Source: Prepared by author

II. Signatory to International Multilateral Environmental Agreements

India is member of almost all major Multilateral Environmental Agreements (MEAs), under four clusters, namely, A. Nature conservation; B. Hazardous material; C. Atmospheric emissions; and D. Marine environment. There are over 500 active agreements/MOUs etc. to which India is signatory. There are 20 major multilateral global MEAs, to which India is a signatory listed in Table C-2.

Table C-2 List of major Multilateral Environmental Agreements, India as signatory

Main clusters and MEAs	
A. Nature Conservation	
- Ramsar Convention on Wetlands - CITES (Convention on International Trade in Endangered Species of Fauna and Flora) - TRAFFIC (The Wildlife Trade Monitoring Network) - CMS (Convention on the Conservation of Migratory Species) - CAWT (Coalition Against Wildlife Trafficking)	- CBD (Convention on Biological Diversity) - ITTC (International Tropical Timber Organisation) - UNFF (United Nations Forum on Forests) - IUCN (International Union for Conservation of Nature and Natural Resources) - GTF (Global Tiger Forum)
B. Hazardous material	
- Cartagena Protocol on Biosafety - SAICM (Strategic Approach to International Chemicals Management) - Stockholm Convention on Persistent Organic Pollutants (POPs)	- Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste and Their Disposal - Rotterdam Convention on Prior Informed Consent (PIC) for certain Hazardous Chemicals and Pesticides in International Trade
C. Atmospheric emissions	
- UNFCCC (United Nations Framework Convention on Climate Change) - Kyoto Protocol	- UNCCD (United Nations Convention to Combat Desertification) - Montreal Protocol (on Ozone Depleting Substances)
D. Marine environment	
- IWC (International Whaling Commission)	

Source: Prepared by author

III. MSW Management System in India

A direct consequence of the combination of hot climate, limited storage space in living premises and a high putrescible content of the refuse in Indian cities is that the collection frequency for municipal solid waste in densely populated areas has to be every day, whereas in many industrialised countries frequencies of one or two times a week are considered adequate to control odours and public health risks. The high inert content of MSW due to the mixing of street sweepings, drain silt, and construction and demolition debris increases the density, which is between 330 and 560 kg/m^3.This means that the vehicles and systems that operate well with low-density wastes in industrialised countries may not be suitable or reliable for Indian cities. Urban solid waste from Indian cities, in general, has low calorific value (1100-1600 kcal/kg) and high moisture content with high percentage of non-combustible materials. However, technologies are available for conversion of energy from MSW through RDF and Mass burning for the mixed as well as segregated wastes available in India. Various states in India are at present taking initiatives to install waste to energy plants. Table C-5 shows recent initiatives of Waste to Energy Plants in India. Taking into consideration the enormity of the problem of MSW management, Municipal Solid Waste Management Rules, 2000 were notified by MoEF&CC. The Rules were revamped in 2016 as Solid Waste Management Rules, 2016.

The Solid Waste Management Rules, 2016 shall apply to every domestic, institutional, commercial and any other non-residential solid waste generator situated in the areas except industrial waste, hazardous waste, hazardous chemicals, bio medical wastes, e-waste, lead acid batteries and radio-active waste, that are covered under separate rules framed under the Environment (Protection) Act, 1986. Every waste generator has the following duties to be complied with as per the rules. The rules mentioned in the Duties and responsibilities of local authorities and village Panchayats of census towns and urban agglomerations that they have to provide all sorts of support and create facilities for SMW to implement the rules.

1. Segregate and store the waste generated by them in three separate streams namely bio-degradable, non-biodegradable and domestic hazardous wastes in suitable bins and handover segregated wastes to authorised waste pickers or waste collectors as per the direction or notification by the local authorities from time to time; Bins for bio-degradable wastes is green, for dry waste / non- bio-degradable / recyclable wastes is white and for other wastes is black.

2. Wrap securely the used sanitary waste like diapers, sanitary pads etc., in the pouches provided by the manufacturers or brand owners of these products or in a suitable wrapping material as instructed by the ULBs and shall place the same in the bin meant for dry waste.

3. Store separately C&D Wastes, as and when generated, in his own premises and shall dispose off as per the Construction and Demolition Waste Management Rules, 2016; and store horticulture waste and garden waste generated from his premises separately in his own premises and dispose of as per the directions of the local body from time to time.

4. No waste generator shall throw, burn or burry the solid waste generated by him, on streets, open public spaces outside his premises or in the drain or water bodies.

5. All waste generators shall pay such user fee for solid waste management, as specified in the bye-laws of the local bodies.

6. No person shall organise an event or gathering of more than one hundred persons at any unlicensed place without intimating the local body, at least three working days in advance and such person or the organiser of such event shall ensure segregation of waste at source and handing over of segregated waste to waste collector or agency as specified by the local body.

7. Every street vendor shall keep suitable containers for storage of waste generated during the course of his activity such as food waste, disposable plates, cups, cans, wrappers, coconut

shells, leftover food, vegetables, fruits, etc., and shall deposit such waste at waste storage depot or container or vehicle as notified by the local body.

8. All resident welfare and market associations shall, within one year from the date of notification of these rules and in partnership with the local body ensure segregation of waste at source by the generators as prescribed in these rules, facilitate collection of segregated waste in separate streams, handover recyclable material to either the authorised waste pickers or the authorised recyclers. The bio-degradable waste shall be processed, treated and disposed off through composting or biomethanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local body.

9. All gated communities and institutions with more than 5,000 sqm area shall, within one year from the date of notification of these rules and in partnership with the local body, ensure segregation of waste at source by the generators as prescribed in these rules, facilitate collection of segregated waste in separate streams, handover recyclable material to either the authorised waste pickers or the authorized recyclers. The bio-degradable waste shall be processed, treated and disposed off through composting or biomethanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local body.

10. All hotels and restaurants shall, within one year from the date of notification of these rules and in partnership with the local body ensure segregation of waste at source as prescribed in these rules, facilitate collection of segregated waste in separate streams, handover recyclable material to either the authorised waste pickers or the authorised recyclers. The bio-degradable waste shall be processed, treated and disposed off through composting or biomethanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local body.

The various treatment of MSW are shown in the Table C-3, Table C-4 and Table C-5. The overall status of municipal waste management based on the available data for 2013-2014 in the country is given below. *Source: CPCB Bulletin Vol.- I, July 2016, Govt. of India.* The Swachh Bharat Mission will definitely help in addressing the 3R indicators.

- House–to-house collection (done partially varies from 40-90%): 18 States
- Segregation (done partially varies from 20 - 80%): 5 States
- Landfill sites identified: 1285
- Landfill sites constructed: 95
- Compost/Vermi-compost facilities operational: 553 ULBs
- Under construction compost/vermi-compost facilities: 173 ULBs
- Pipe composting: 7000 in Kerala
- RDF/Pellet facilities: 12 Nos.
- Biogas Plant: 645 Nos (600 in Kerala).
- Energy Generation Plant: 06
- Waste Generation: 1,41,064 TPD
- Waste Collected: 1,27,531 TPD(90%)

- Waste processed: 34,752 TPD (27%)
- Landfilled waste: 4,515 TPD

After the implementation of the Swachh Bharat Mission (SBM), a significant improvement has taken place in the status of compost plants. The five states having highest number of functional /sub optimal compost plants are, Karnataka has 23, Maharastra has 17, Andhra Pradesh has 15, Gujarat has 12 and Tamil Nadu has 10 as in July 2017. As in July 2017, the total number of functional /sub optimal compost plants is 145 which was 45 in April 2016, the total annual production of compost in the functional /sub optimal plants is 1.3 million tones/annum and in April 2016 the annual production was 0.15 million tones/annum, the number of plants under construction/up-gradation/revival is 150 that was only 95 in April 2016 and the capacity of under construction/up-gradation/revival is 3.3 million tones/annum in July 2017 whereas the same was 2.2 million tones/annum in April 2016 (MoUD, 2017).

Table C-3 Number of composting / vermin-composting plants in some states

State	Number of plants(Composting/ vermin-composting)	State	Number of plants (composting/ vermin-composting)
Andhra Pradesh	32	Madhya Pradesh	4
Chhattisgarh	15	Maharashtra	125
Delhi	3	Meghalaya	2
Goa	5	Orissa	3
Haryana	2	Punjab	2
Gujarat	86	Rajasthan	2
Himachal Pradesh	13	Tripura	13
Karnataka	5	Uttarakhand	3
Kerala	29	West Bengal	9

Source: CPCB (2013).

Table C-4 Number of energy recovery plants in some states

State	No. of RDF plants/ waste to energy plant (PP)/Biogas (BG)	State	No. of RDF plant/ Waste to Energy Plant/Biogas (BG)
Andhra Pradesh	3-RDF, 4 PP	Delhi (UT)	1-RDF, 1PP
Chandigarh (UT)	1-RDF	Gujarat	2-RDF
Chhattisgarh	1-RDF	Kerala	2-BG
Maharashtra	19-BG	Madhya Pradesh	1--RDF

Source: CPCB (2013).

Table C-5 Recent initiatives of Waste to Energy Plants in India (As in 2017)

State	WTE Plant Location/capacity	Status of initiative
Delhi	Okhla (2000 TPD),	Okhla plant running, One commissioned, One under construction
Madhya Pradesh	600 TPD at Jabbalpur, Indore, Bhopal	Jabbalpur generating power to grid, others are in contract stage
Gujarat	Surat, Vadodara, Mahar (3000TPD)	Contract stage
West Bengal	Kolkata, and Howrah	Tendering Stage
Andhra Pradesh / Telengana	Four Locations; Karimnagar	Tendering Stage Operation stopped
Maharashtra	Pune two	One failed, one in tender stage
Bihar	One Plant	Tendering Stage

Source: CPCB Report, 2013

The waste generated is collected from door to door from different sources - households, commercial and industries. In some of the cities, the wastes are collected by refuse containers. The collected wastes are transported by the Municipality / Municipal Corporation and/or the private agencies to the transfer station. The waste is transferred from the source to the transfer stations where after partial separation, the corresponding feed material is sent to the respective treatment facility wherever exists or sent to the landfill or dumpsites. The disposal costs are taken in form of the tax. The institutions collect their waste in an institutional refuse and then by their private agent transfer the waste to the transfer station. The transfer of the waste is done by various modes of transport like bicycles, carts, motorized vehicles etc. In rural areas there is still existence of waste being transported by the animal-carts. Figure C-3 (A) and Figure C-3(B) shows the per capita generation of MSW selected cities in 2000 and 2011 and Figure C-4 shows the supply chain framework of the waste management in India. The collection efficiency of selected Indian states (CPCB, 2013) in shown in Figure C-5.

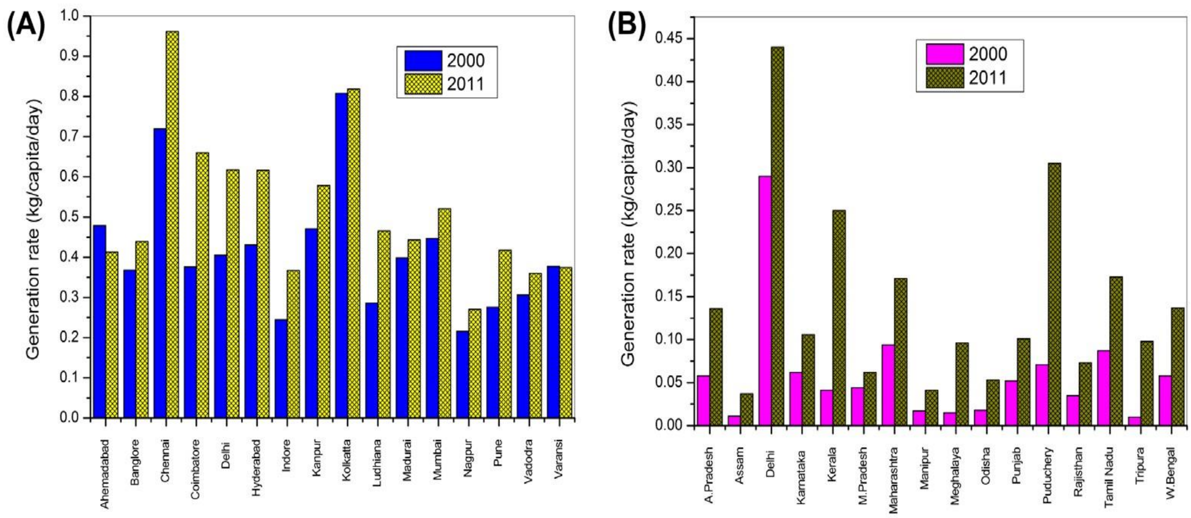
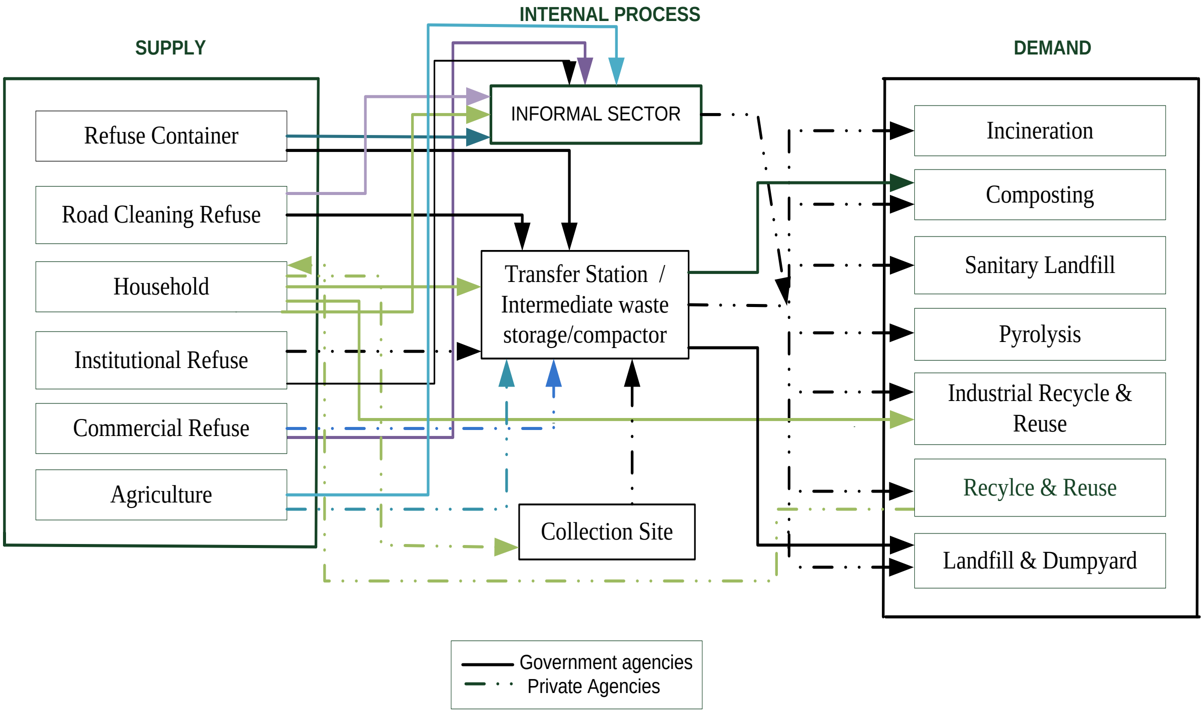
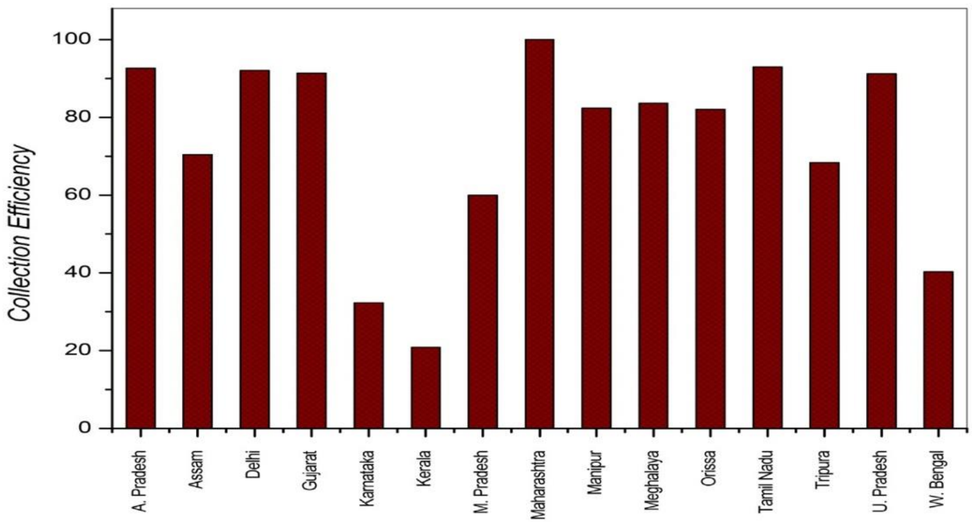


Figure C-3 (A): Per capita generation of MSW selected Indian cities in 2000 and 2011,
(B): Per capita generation of MSW in selected Indian states in 2000 and 2011



Source: Ghosh, et al, 2016

Figure C-4 MSW Supply Chain Framework in India (Source: Ghosh, et al, 2016)



Source: CPCB, 2013

Figure C-5 Collection efficiency of Solid Waste selected Indian states

IV. Recent and future policy trends on 3Rs and waste management area (future)

Waste generation in Indian cities will increase five-fold to touch 260 million tonnes per year by the year 2047 (TERI 2014). The recent Rules pertaining to different categories of wastes management put great emphasis on waste minimization and 3R promotion. The proposed strategies include,

- Defining the roles and responsibilities of various stakeholders and putting in place an operating framework.
- Greater emphasis on civic engagement by involving public and NGOs.
- Establishing Institutional mechanism at State Level for planning, technical, financial and implementation support.
- Promoting public private partnership (PPP) investments for developing treatment and final disposal facilities on Regional level on Cluster based approach.

Organizing door-to-door collection of waste to be the irreversible strategic approach to prevent residents from dumping their garbage out. The waste collected from door-to-door is to be source segregated and collected separately in wet and dry waste from all sources. ULBs are to encourage decentralized, community-managed primary collection system preferably managed by community based organisations (CBOs) such as residents' associations, and welfare societies that will be financially assisted and equipped for the purpose. Primary vehicles are to be used to collect and transported waste from lanes and by-lanes to the main roads synchronizing with bulk transportation vehicles. The collected waste will be transported in the segregated form (wet and dry) by vehicles, at the primary collection and secondary/ bulk collection systems. Waste will be handled mechanically across the MSW value chain with minimum human contact with waste.

Participatory approaches are proposed for promotion of biodegradable and recyclable substitutes for non-biodegradable materials like plastics and develop systems for their recycle, reuse, through promotion of relevant technologies, and use of incentive based instrument. Each ULB will be encouraged to identify land to establish Dry Waste Sorting facilities (Material Recovery Facilities) wherever possible through social entrepreneurs, common interest groups of informal sector like Women Self Help Groups (SHGs) and Resident Welfare Associations (RWA).

ULBs are mandated to raise the awareness of city stakeholders through regular meetings with households, establishments, industries, elected representatives, municipal functionaries, media, etc. Landfills and other waste management facilities are to be regionally shared, clubbing of multiple municipalities and creation of clusters, accompanied by regional cooperation and fair cost-sharing arrangements. Phasing out and upgrading old open dumps in the ULBs and reclamation of the dumpsites through recovery of the decomposed matter through 'Bio-mining' and capping of the non-biodegradables in scientific manner is mandated. Treatment of segregated waste is to be done through appropriate technologies based on the feasibility, characteristics and quantities of waste. The technology options could be Composting, Biomethanation, Waste to Energy, Co- Processing of dry segregated rejects in cement/ power plants, utilization of construction and demolition debris and any other options as endorsed by the CPCB.

Technical Cell with experts are to be setup to extend support to the ULBs in identifying sites for processing, treatment and landfill facilities, PPP models, technologies, structuring and financing of projects including implementation and monitoring of the Mechanical Composting, Biomethanation, Waste to Energy and Co- Processing in cement/ power Projects.

V. Major 3R related technologies

The fact that a large part (50 - 60%) of India's waste is biodegradable, provides an opportunity for composting. While lifestyle changes, especially in the larger cities, are leading to increased use of packaging material, and per capita waste generation is increasing at about 1.3% per annum, the biodegradable component is still expected to be much higher than in industrialized countries. The urban local bodies (ULB) in India are currently exploring various methods for waste processing and disposal, adopting appropriate combination of technologies to best suit local situations. These technologies will have to meet the minimal requirements and standards for end products, emissions and discharges, laid down by the relevant legislations.

The Technology Advisory Group (TAG) set up by the Ministry of Urban Development, Government of India, made a serious attempt to examine the different technological options available worldwide (TAG Report, 2005). The larger proportion of biodegradable matter in MSW indicates the desirability of biological processing (Composting or Biomethanation) of waste. Composting of MSW is considered as the most important technology for the biological processing and recycling of biodegradable organics and nutrients. Full scale composting technology for source separated MSW, mechanically separated MSW and mixed MSW is already commercially available and in use, though its application is often limited by process economics, compost quality and availability of markets for compost. It is critical that the compost so produced shall be environmentally safe, particularly regarding heavy metals and it should be ensured through proper testing and certification.

As per the Report of the Task Force on Waste to Energy, published by NITI Aayog (erstwhile Planning Commission) in 2014, only 22 States/UTs have set up waste processing and disposal facilities. As per this Report, 279 Conventional composting, 138 vermi-composting, 7000 Pipe composting is 7000 in Kerala,172 biomethanation, 29 Refuse Derived Fuel (RDF) and 8 Waste to Energy (WtE) plants are reported to have been establish. Nearly 4.7 million micro, small and medium sized biogas plants have already been installed in the country up to 31st March, 2014. Bigger biogas plants are also installed in several industries. The biggest biogas & bottling plants in India is at Kannahalli, Bangalore of 300 TPD presently operational at 150 TPD and in Gujarat 110 TPD. Ministry of New and Renewable Energy (MNRE) is implementing the National Biogas and Manure Management Programme (NBMMP) in all the States and UTs of the country has fixed a target of 1,00,000 biogas plants for 2016-17 for setting up of family type biogas plants in rural and semi-urban areas of the country (source:http://pib.nic.in/newsite/PrintRelease.aspx?relid=148110; Aug 01, 2016). Home Composting as well as composting in ULBs in India is now encouraged for resource utilization and disposal of least amount to landfill.

National Institute of Urban Affairs have documented several initiates to improve waste segregation, waste recovery, scientific waste disposal as well as planning, policy and enforcement initiatives from different Indian cities (NIUA, 2015). Biological processing of mixed municipal waste yields low quality compost which may have contaminants in excess of permissible limits. Several large scale mechanical compost plants in India have failed on account of the high sophistication of the plant, leading to difficulties with operation and maintenance and prohibitive costs. Such plants have produced poor quality compost due to use of mixed municipal wastes as feedstock. In Bangalore exists a very enthusiastic initiative of Eco group activities. The Eco group members in the city monitors and participate in the waste management activities and thus in many of the wards, mainly by Yalahanka Eco Group could achieve 100% segregation of waste. A few large-to-medium plants are still operating with simpler technology, and with government subsidies, e.g. the autonomous Karnataka Compost Development Corporation plant in Bangalore, in Dhapa dumpsite of Kolkata 500 TPD compost plant and in some other cities. There are a number of initiatives in different cities. In Kolkata Municipal Corporation including Kolkata Municipal Areas with 41 municipalities, more than 120 compactors have been installed in different wards which are used to compact the un-segregated solid wastes collected from door to door and transported to the dumping ground. The initiative has made the city cleaner but the environmental concern like resource utilization through source segregation, composting, energy recovery has not been addressed. In some wards in KMC, namely 115, 120 and other five has installed source segregation, MRF etc. Encouraged by the move for public-private partnerships in solid waste management, the interest of private companies in composting is reviving. The units are often set up by agro-chemical companies that receive assistance from municipalities in the form of access to free municipal wastes, and a rent-free site, as is the case with the Excel Industries plant in Bombay and some of the company's franchises. The proliferation of thin plastic bags and mix up of household hazardous wastes such as batteries is a threat to any types of composting in Indian cities. Neighbourhood scale compost plants, promoted by NGOs or CBOs, with assistance (such as access to land) from municipal councils, are relevant for the solid waste reduction of small and medium size cities. The new initiatives of the government of India will encourage the compost production. The Fertilizer producing companies are obligated to purchase all compost manufactured by respective cities to which they have been tagged. The Market Development Assistance (MDA) of Rs. 1500 per metric tonne of city compost will be paid to fertilizer marketing companies; The rules have been amended on 28th August 2016 that the ULBs/Compost Manufacturers can market compost directly to farmers and claim MDA of Rs. 1500 per tonne. Government of India provides Viability Gap Funding of 35% to states to set up new compost plants

Producing compost acceptable in quality and price to buyers, on the scale that can significantly reduce urban organic solid waste, would seem to require large-scale 'separation at source' and a mechanism to separately collect such wastes by households and bulk generators (food processing plants, wholesale market terminals, green markets, large hotels, large restaurants, large institutions, parks). It is important to note that in addition to waste-generator cooperation, the separate collection of residential organics on a large scale requires radical changes in existing solid waste management systems. An approach that does not demand complete waste generator compliance with separation is doorstep sorting by waste collectors. It is being currently applied in many Indian cities. Attempts to link composting with urban food production, or with plant nurseries and parks' improvement deserves to be seriously examined as part of a waste management strategy to ensure sustainability of compost plants.

The biodegradable organic fraction separated from MSW could also be used as a feedstock for anaerobic digestion to produce biogas and compost. Food wastes and other putrescible wastes such as market wastes and slaughter house wastes which may be too wet and lacking in structure for aerobic composting are ideal inputs for biomethanation. The Ministry of Non-conventional Energy Sources (MNES), Government of India is looking forward to biomethanation Technology as a secondary source of energy by utilizing industrial, agricultural and municipal wastes. The local availability of the anaerobic technology in India is limited to smaller capacities applied to vegetable and slaughter wastes.

The first large scale biomethanation plant to generate 5 MW power utilizing 300t/day of MSW at Lucknow, at a cost of Rupees 760 million commissioned in 2005 could not function to its design capacity due to the poor quality (very high content of inerts) of input materials. The Plant had a number of state-of-art technologies (screening, hand sorting, magnetic separation, size reduction, ballistic separation, pulping and grit removal, etc) to segregate wastes as per requirements for functioning of the anaerobic digesters. A biomethanation plant to generate electricity from 30 tonnes of vegetable waste setup at Koyambedu Wholesale Market Complex in Chennai at a total cost of Rs. 50 million could generate electricity to the tune of 230 kw per day and compost of 10 tonnes per day. This Plant is also facing difficulties in sustaining its operation, mainly due to poor quality of inputs. The homogeneity of the feed material is an important parameter from the efficiency point of view. The solid waste management system needs to be modified and improved to make source separation and separate collection of solid waste. Or else the applicability of biomethanation will be limited to highly organic and homogenous waste streams like Market wastes.

Waste to Energy (WtE) by thermal or biological route is in a nascent stage in India and most WTE initiatives are heavily dependent on subsidies being provided by various government agencies, primarily the MNES. Thermal processing of waste becomes viable only if sufficient high calorific value components (such as paper, plastic) are present in the waste. Thermal processing technologies such as Mass burn incineration is not a realistic option in India for technical and financial reasons since Indian MSW has low calorific value, high moisture content and high inorganic matter leading to high economic and environmental costs. Though Refuse Derived Fuel (RDF) based plants have been reported to be technically feasible, the details need to be carefully considered with reference to the volumes and nature of the wastes accepted and the quantity and mode of disposal of the rejects including the emission controls. The Department of Science and Technology more than a decade back developed a technology of processing MSW into fuel pellets and transferred to M/s Selco International for scale up and commercial operation by setting up a 6.6 MW power plant. A similar plant was also setup in Vijayawada. The cost economics of WtE plants are such that these can be considered as an option for disposal of solid wastes, only as part of integrated waste management largely in metro cities of India. Pyrolysis/Gasification are already established for homogenous organic matter, while Plasma Pyrolysis is relatively new technology for disposal of particularly biomedical wastes and hazardous wastes. These are now being recognized as an attractive option for disposal of solid wastes also as proper destruction of waste is ensured. Local bodies have not so far preferred WtE projects in some States. However, Waste-to-Energy projects are coming up in the state of Andhra Pradesh, Gujarat, Maharashtra & Delhi with total 76 waste-to-Energy related projects [RDF/pellet-22, Biogas Plants-41 and Power Plant-13] established. Very recently in Jabalpur in the state of Madhya Pradesh, a 600 TPD WtE plant using mass burning technology of mixed MSW started generating 8 MW power in late 2016. At present seven WtE plants are in operation in India with a total of 84 MW capacity. 53 WtE plants with total capacity of 405.3 MW are in progress having different stages of work, e.g., tendering stage, tender finalization stage and under construction stage. The Central Electricity Regulator Commission (CERC) has notified generic tariff for WtE plants based on mixed waste and RDF (Refuse Derived Fuel). The Ministry of Power, Govt. of India has revised the tariff policy 2006 under India Electricity Act, 2003 making it mandatory for DISCOMS to purchase power from WtE Plants. All industrial units using fuel and located within 100 km from a solid waste based RDF plant may replace at least 5% of their fuel by RDF so produced.

As per the Annual reports of CPCB 2013-14, 535 waste processing plants (compost & vermin-compost) have been set up in 375 ULBs. Some of these facilities are shared by 2/3 ULBs. These waste processing plants cover treatment of wastes partly or fully. Waste processing plants are under construction in 107 ULBs. Till the year 2012-13, establishment of as many as 645 compost/vermin-compost plants were reported including the number of many decentralized vermin-compost plants within municipal areas. The operation status and actual number of such facilities vary with time as some of the plants are coming new whereas some plants become non-functioning. There are 95 functional/sub optimal compost plants in the country with a production capacity of 2.36 million tonnes/annum. At present, total production of city compost from these plants is approximately 0.330 million tonnes/annum. Additionally, there are 313 plants under construction/up gradation/revival with a capacity of 2.31 million tonnes/annum. Cumulatively, taking into consideration both functional and under construction compost plants the production capacity is set to reach 4.67 million tonnes/ annum by March 2018 (Source: Circular dated 13 January 2017 of MoUD, GoI, http://www.swachhbharaturban.in/sbm/home/#/SBM). For scaling up production and consumption of compost, the Ministry of Chemicals and Fertilizers (MoC&F) in collaboration with MoUD has now released operational guidelines to an amendment in the policy on the '*Promotion of City Compost'* which now allow the ULBs to market compost directly to farmers and claim market development assistance of Rs.1500 per tonne. Eco-Mark standard for City Compost would ensure that environment friendly quality product reaches the farmers. Composting can reduce the volume of waste to landfill/dumpsite by converting the waste into useful by-products (Khajuria et al., 2010). This also prevents production of harmful greenhouse gases (especially methane) and toxic material that pollutes groundwater apart from polluting the environment.

Sanitary landfills are the final means of disposal for inerts and residues from waste processing. The decision to implement any particular technology for processing of MSW depends on number of factors including

- ✓ Site specific circumstances such as cost of waste transportation, scale of treatment, local socio economic conditions.
- ✓ Origin and Quality of wastes.

- ✓ Presence of hazardous/toxic wastes.
- ✓ Availability of outlets for the products such as compost and energy.
- ✓ Energy price and buyback tariff.
- ✓ Level of capital investments and cost of labour.
- ✓ Land availability and costs.
- ✓ Pollution control measures and costs.
- ✓ Level of understanding of the decision makers in ULBs

Local bodies are cautioned not to adopt expensive technologies of power generation, fuel pellatization, incineration etc., until they are proven under Indian condition. The challenges of medium or small municipalities related to finding land for waste disposal, getting enough funds for its construction and operation, finding the technical personnel to operate the heavy machinery. With the availability of land for processing and disposal of wastes becoming scarce, measures for conservation of land and organic resource shall be taken and organics shall be returned to soil, encouraging public, NGO/CBO participation. The recyclable wastes shall be passed on to recycling industry. Fighting the opposition from the neighborhoods can be handled easily if a group of neighboring municipalities creates a common landfill facility on a cost-sharing basis on a large parcel of land at a suitable location away from the cities. The operation and management may be handled through a professional agency, the cost of which is shared by the participating municipalities in the form of tipping fees proportional with the waste delivered to the landfill site for disposal. Municipalities considering such regionalized waste disposal facilities should recognize that the costs and benefits, although shared, will not necessarily be identical for all communities. For example, a community that sends its waste to a facility shared with another municipality benefits from not having to site and manages the landfill within its jurisdiction. However, it will probably be subject to fees levied by the community in which the waste management site is located. Regionalization sometimes can require that waste be transported over long distances and through neighboring areas and communities. Municipalities should explore these and other potential barriers thoroughly and consider the tradeoffs of sharing common facilities.

VI. Current and future investment plans, including mega projects, master plans, infrastructure

Government of India has launched “Swachh Bharat Abhiyan (Clean India Mission)” (SBA) on 2nd October, 2014, “Atal Mission for Rejuvenation and Urban Transformation (AMRUT)” and “Smart City Mission” on 25th June, 2015(NITI Aayog, 2015). The Mission covers all 4041 statutory towns/cities as per 2011 census. Solid waste management is one of the admissible components under SBM. The SBA provides to make the country clean by 2nd October, 2019 from the point of view of Solid Waste Management whereas the other Missions require the State Government to set up new sewage treatment plants as per their requirement. In addition, Ministry of Urban Development supplements the efforts of State Governments/Urban Local Bodies (ULBs) for efficient sewage, waste and garbage management by issuing guidelines/advisories/Manuals from time to time. The Mission, among other measures, includes Solid Waste Management for which there is a provision for 20% of project cost as Viability Gap Funding where State Governments or Urban Local Bodies can opt for any feasible waste processing technology. Under the SBM, nearly

902 cities have been certified as open Defecation free (ODF), nearly 0.23 million CT/PT built under construction, WtE under construction for 88.4 MW, nearly 23 % of wastes are being processed, over 50% unban wards have achieved 100% door to door collection of solid wastes and nearly .01313 million tonnes compost is being produced (Figure C-6). The figure also shows the good performing, accelerating performance and acceleration required in performance in different states in India.

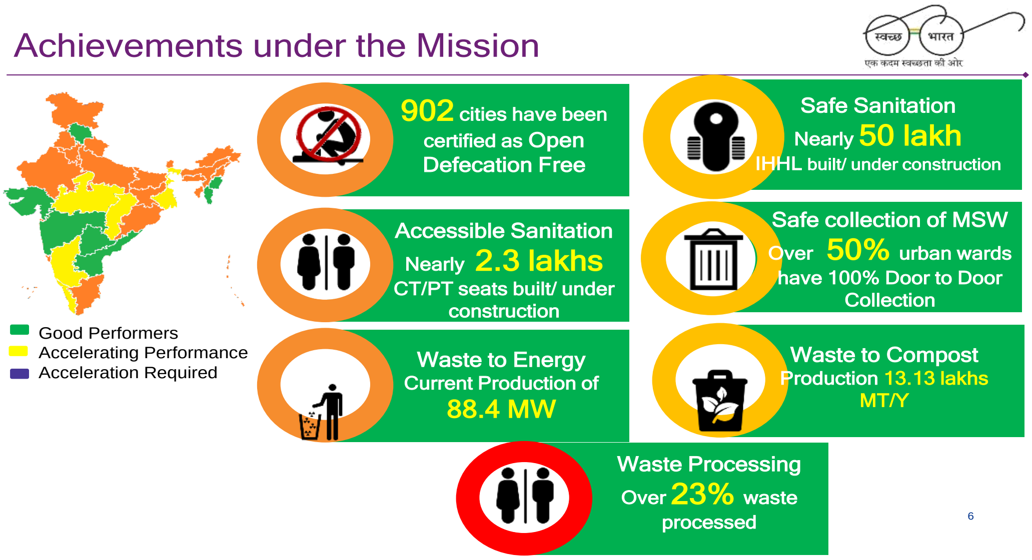


Figure C-6 Achievement under Swachh Bharat Mission *SBM reporting, MoUD 2017*

The state laws governing municipal authorities establish their powers to levy taxes, charges, fees, and the like for raising money to meet their statutory obligations. Some municipalities also levy monthly user fees or charges for water, drainage, and sanitation to meet the necessary operating and maintenance cost of the service. By and large, however, municipal authorities suffer a major deficit of funds to meet their obligations. Municipalities can obtain grants such as

- 14th and 12thState Finance Commission grants.
- Jawaharlal Nehru National Urban Renewal Mission (JNNURM) grants.
- Clean India Mission Grant
- Swachh Bharat Mission Grant
- AMRUT Urban Infrastructure Development for Small and Medium Towns (UIDSSMT) scheme grants.
- Smart City Programme being implemented from the year 2016 at national level in 100 cities.

Started in the year 2005, the JNNURM cover 63 selected towns and the UIDSSMT cover 5098 urban towns for providing infrastructure facilities including solid waste management in a seven year Mission period. The 12th Finance Commission had taken a very considered view for improving urban infrastructure and allotted Rs.5000 crores for supplementing the resources of the ULBs in the country during 2005-2010. Out of this amount, 50% was earmarked for improving SWM Services.

The Ministry of Urban Development have created a Community Participation Fund (CPF) under which a community can conceive a project on municipal solid waste and submit it through the local Municipality to the Union Government. Funds to the tune of Rs. 9.5 lakh can be granted with community contributing 5% in case of slums and 10% in case of others. The Ministry of Agriculture (MOA) and the Ministry of Environment and Forests (MOEF) have been actively promoting waste composting, while the Ministry of New and Renewable Energy has designed schemes to promote waste-to-energy projects. In addition to financial and technical support from central and state governments, the following incentives are available for financing solid waste infrastructure in urban areas.

- Tax Exemption of Certain Bonds Issued by Local Authorities.
- Tax Holiday for the Project Entity for Solid Waste Management.
- Tax Exemption for Income of Infrastructure Capital Funds and Companies.
- Availability of Funds by Sale of Carbon Credits.
- Sectorial Lending by Financial Institutions and Multilateral Donors.

The role of the private sector in financing resource recovery (composting, waste-to-energy) facilities is growing in India, particularly for door-to door collection of solid waste, street sweeping, transportation and for treatment and disposal of waste. Cities which have pioneered in public private partnerships (PPPs) in SWM include Bangalore, Chennai, Hyderabad, Ahmadabad, Surat, Guwahati, Mumbai and Jaipur. The irony is that Municipal decision makers do not give adequate priority to SWM and even most of the budget for SWM is consumed in salaries of sanitation workers and transport of waste. Very little or none is set apart for actual treatment and disposal of waste. The municipal authorities need to seriously consider introducing a sanitation or SWM Cess to meet the cost of service. User charges can be an equitable means of funding SWM services if properly administered. Waste recycling, composting, and waste-to-energy operations may generate operating revenues or at least reduce the cost of waste treatment.

As the present capacity of municipalities in India to manage the privatization process is quite limited, there is need for developing in-house financial and managerial capability to award contracts to private sector and monitoring services provided by the private operator since the onus of ensuring proper service delivery and compliance of standards lies with the local bodies. The principle of polluter pays, which requires the person or organization generating waste to bear the full cost of waste management, needs to be put into practice, so that the polluter will have the incentive to minimise the cost and amount of waste generated. The application of the principle involves establishing a fee collection system that represents the true costs of waste management and charged in proportion to the amount of waste generated. It is also important to identify who is the polluter, which in the case of MSW will be the individuals and commercial suppliers.

D: 3R INDICATORS

I. Total MSW Generated and Disposed and MSW Generation Per Capita

As per the Press release dated 05-April-2016 by the Information Bureau, Government of India, Ministry of Environment, Forests and Climate Change (MoEF&CC), the minister of MoEF&CC pointed out that 62 million tonnes of waste is generated annually in the country at present, out of which 5.6 million tonnes is plastic waste, 0.17 million tonnes is biomedical waste, hazardous waste generation is 7.90 million tonnes per annum and 1.5 million tonnes is e-waste. He added that the per capita waste generation in Indian cities ranges from 200 grams to 600 grams per day. The minister underlined the fact that 43 million TPA is collected, 11.9 million is treated and 31 million is dumped in landfill sites, which means that only about 75-80% of the municipal waste gets collected and only 22-28 % of this waste is processed and treated. Waste generation will increase from 62 million tonnes in 2016 to about165 million tonnes in 2030. (Source: http://pib.nic.in/newsite/ PrintRelease.aspx?relid=138591)

The socio-economic structure of the Indian society not only makes per capita generation of waste much low compared to that of the western societies. A substantial amount of MSW is recycled and reused through the primary intervention of rag pickers and second-hand markets, though there are problems like the health hazard to the rag pickers and the degradation and devaluation of the recyclables. The survey conducted by CPCB through different research organisations in India revealed that the total waste generation in 2011 was 127.485 million tonnes per day whereas in 2014 the amount was 141.064 million tonnes per day, the details data are given in Table D-1 to Table D-4 and Figure D-1 and Figure D-2. This may be noted that the data compiled by different agencies have lots of dissimilarities.

A report by CPCB (2008) in 59 cities [35 metro cities and 24 state capitals] appended in Table D-3, has revealed that the composition of municipal solid wastes (MSW) varies with size of city and income group (Kumar et. al, 2009). The MSW at generation sources and collection points in India consist of a large organic fraction (40–60%) and inerts (30–40%) with low recyclables in terms of paper (3–6%) and plastic, glass and metals (each less than 1%).

Many of the towns/ cities are not having proper action plan for implementation of the MSW Rules 2016.As per the CPCB Report on Municipal Solid Waste (2012), waste collection is observed only 70% of total waste generation and the remaining 30% lost in the urban environment. House-to-house collection and segregation not fully covered in many cities. There is a large gap in between Waste collection and processing. Most of the municipalities have no sanitary landfill facility and follow dumping for disposal of MSW. MSW generation is a fundamental indicator since municipalities usually prepare annual budgets on MSW management based on annual MSW generation (collection). The use of total MSW generation and MSW generation per capita indicators would enhance governmental planning and decision-making capacity in the management.

Impact of Population Growth on Municipal Solid Waste (MSW) Generation Population growth and rapid urbanization means bigger and denser cities and increased MSW generation in each city. The data compiled for this report indicates that 366 cities in India were generating 31.6 million tonnes of waste in 2001 and are generating 47.3 million tonnes in 2011, a 50% increase in one decade in 2011-12. It is estimated that these 366 cities will generate 161 million tonnes of MSW in 2041, a five-fold increase in four decades. At this rate the total urban MSW generated in 2041 would be 230 million TPY (630,000 TPD). With an astounding 26,820 tonnes of solid waste per day (TPD), Maharashtra has topped the list of most solid waste producing states in India, according to the Central Pollution Control Board (CPCB). Uttar Pradesh, generates 19,190 TPD solid wastes is ranked second. Cities like Pune, Mumbai, Delhi, Chennai, Kolkata and Bangalore were found to be the major contributors of municipal waste. Table D-5 shows the Population Growth and Impact on Overall Urban Waste Generation and Future Predictions until 2041.

Table D-1 Total MSW generated, collected and MSW per capita generation

Indicator	Data	Unit	Year	Reference
Total MSW generation	0.141064	million tonnes/day	**2014**	CPCB, GoI
MSW generation per capita	200 – 600	gms/day/person	**2016**	CPCB, GoI
Waste Collected	0.1,27,531(90%)	million tonnes/day	**2014**	CPCB, GoI
Waste processed	0.034,752 (27%)	million tonnes/day	**2014**	CPCB, GoI

Prepared by author

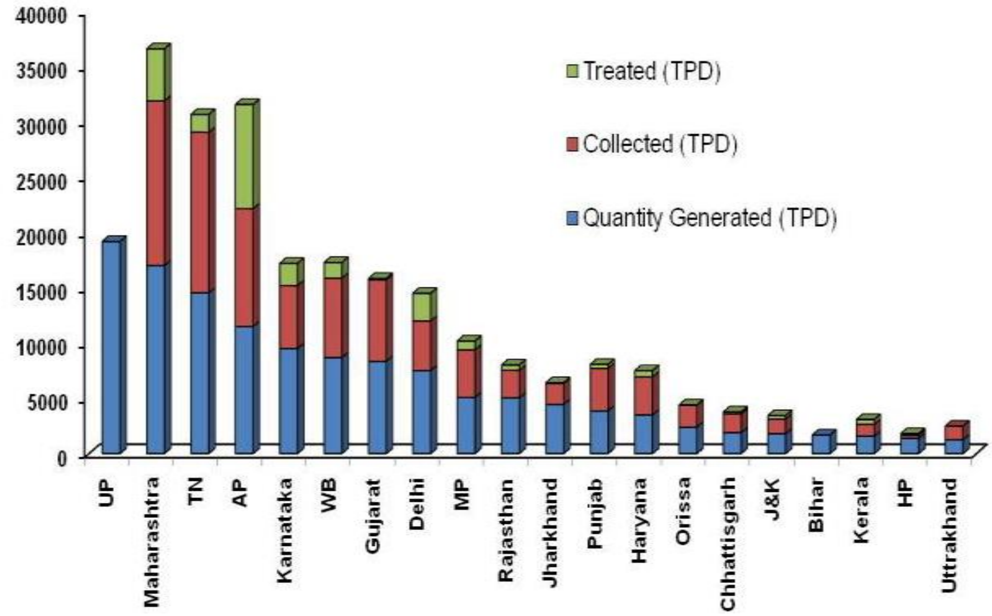
Table D-2 Municipal Solid Waste Generation data for states/ Union Territories in India (CPCB, 2012)

Sl. No	Name of the State & Union Territories (UT)	(a) Municipal solid Waste MT/ day 1999-2000			Population as per census 2011**	(c) Municipal solid Waste MT/ day (2009-12)
		Class-I cities	Class-II Towns	Total		
1.	Andaman & Nicobar (UT)	-	-	-	379,944	50
2.	Andhra Pradesh + (New State: Telengana)	3943	433	4376	49,386,799+ (35,286,757)	11500
3.	Arunachal Pradesh	-	-	-	1,382,611	93.802
4.	Assam	196	89	285	31,169,272	1146.28
5.	Bihar	1479	340	1819	103,804,637	1670
6.	Chandigarh (UT)	200	-	20	1,054,686	380
7.	Chhattisgarh	-	-	-	25,540,196	1167
8.	Daman Diu & Dadra (UT)	-	-	-	242,911	41
9.	Delhi (UT)	4000	-	4000	16,753,235	7384
10.	Goa	-	-		1,457,723	193
11.	Gujarat	-	-	-	60,383,628	7378.775
12.	Haryana	3805	427	4232	25,353,081	536.85
13.	Himachal Pradesh	623	102	725	6,864,602	304.3
14.	Jammu & Kashmir	35	-	35	12,548,926	1792
15.	Jharkhand	-	-	-	32,966,238	1710

Sl. No	Name of the State & Union Territories (UT)	(a) Municipal solid Waste MT/ day 1999-2000			Population as per census 2011**	(c) Municipal solid Waste MT/ day (2009-12)
		Class-I cities	Class-II Towns	Total		
16.	Karnataka	3118	160	3278	61,130,704	6500
17.	Kerala	1220	78	1298	33,387,677	8338
18.	Lakshadweep (UT)	-	-	-	64,429	21
19.	Maharashtra	8589	510	9099	112,372,972	19.204
20.	Manipur	40	-	40	2,721,756	112.9
21.	Meghalaya	35	-	35	2,964,007	284.6
22.	Mizoram	46	-	46	1,091,014	4742
23.	Madhya Pradesh	2286	398	2684	72,597,565	4500
24.	Nagaland	-	-	-	1,980,602	187.6
25.	Orissa	646	9	65	41,947,358	2239.2
26.	Puducherry(UT)	60	9	69	1,244,464	380
27.	Punjab	1001	265	1266	27,704,236	2793.5
28.	Rajasthan	1768	198	1966	68,621,012	5037.3
29.	Sikkim	-	-	-	607,688	40
30.	Tamil Nadu	5021	382	5403	72,138,958	12504
31.	Tripura	33	-	33	3,671,032	360
32.	Uttar Pradesh	5515	445	5960	199,281,477	11.585
33.	Uttaranchal(New Nmae: Uttarakhand)	-	-	-	10,116,752	752
34.	West Bengal	4475	146	4621	91,347,736	12557
	Total	**48134**	**3991**	**52125**	**1,210,193,422**	**127,485.107**

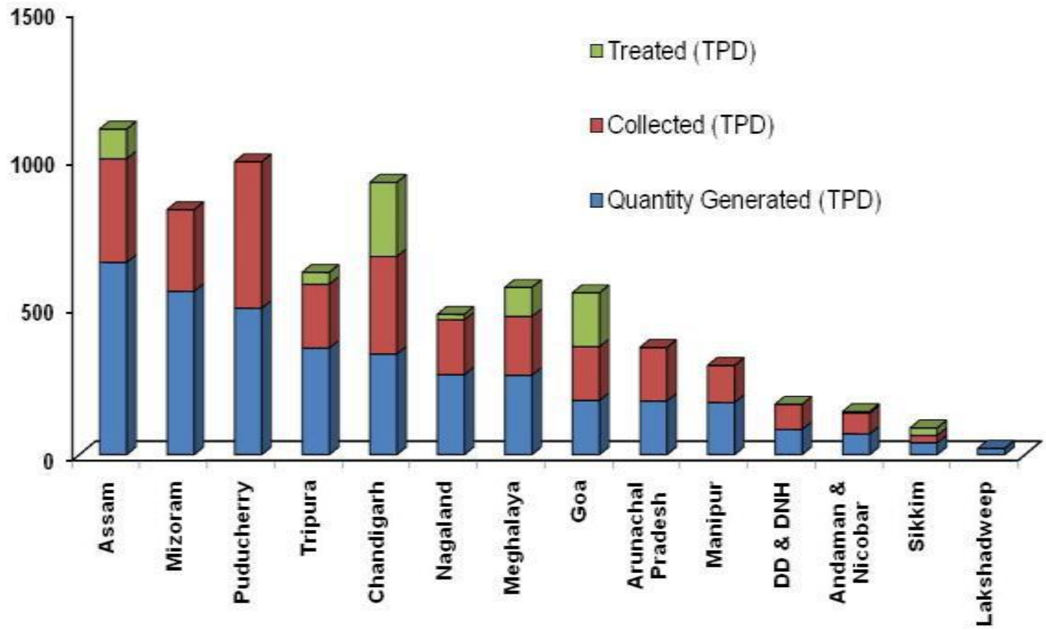
**Based on CPCB's study conducted through;a) EPTRI, b) As reported by SPCBs / PCCs (during 2009-12).Ved2008-10-26.*
*** India Census 2011, Provisional Population Totals*

Generation of solid waste continues to increase in urban India as evident from the daily waste generation data for major Indian cities presented in Table D-3 to Table D-6. This could be due to rapid urbanization, rising incomes and changing consumption patterns. The per capita generation of MSW in India, vary from 200 g to 800 g per day depending on the socio-economic status and cultural habits, climate, location, urban structure, density of population and extent of non-residential activities (CPCB, 2012). Due to increasing per capita waste generation at the rate of about 1.3% per year, and growth of urban population between 3% and 3.5% per annum, yearly increase in the overall quantity of solid waste in the Indian cities is estimated to be about 5%. Table D-5 shows the population Growth, Per Capita MSW generation and Impact on Overall Urban Waste Generation and Future Predictions until 2041 and Table D-6 present the generation of Municipal Solid Waste (MSW) in Class-I cities in selected states in 1999 (CPCB).



Source: Prepared by author

Figure D-1 Average waste generation, collection and treatment in TPD in 2013 -14 and 2012-13 in 20 states in India



Source: Prepared by author

Figure D-2 Average waste generation, collection and treatment in TPD in 2013 -14 and 2012 -13 in 14 smaller states including hilly states and union territories

Table D-3 Municipal Solid Waste Generation (Tonnes/day) data for Metro Cities/State Capitals of India (CPCB, 2012)

Sl. No.	Name of City	* Municipal Solid Waste (Tonnes per day)		
		1999-2000(a)	2004-2005 (b)	2010-11 (c)
1.	Agartala	-	77	102
2.	Agra		654	520
3.	Ahmedabad	1683	1302	2300
4.	Aizwal	-	57	107
5.	Allahabad	-	509	350
6.	Amritsar	-	438	550
7.	Asansol	-	207	210
8.	Bangalore	2000	1669	3700
9.	Bhopal	546	574	350
10.	Bhubaneswar	-	234	400
11.	Chandigar	-	326	264
12.	Cheennai	3124	3036	4500
13.	Coimbatore	350	530	700
14.	Daman	-	15	25
15.	Dehradun	-	131	220
16.	Delhi	4000	5922	6800
17.	Dhanbad	-	77	150
18.	Faridabad	-	448	700
19.	Gandhinagar	-	44	97
20.	Gangtok	-	13	26
21.	Guwahati	-	166	204
22.	Hyderabad	1566	2187	4200
23.	Imphal	-	43	120
24.	Indore	350	557	720
25.	Itanagar	-	12	102
26.	Jabalpur	-	216	400
27.	Jaipur	580	904	310
28.	Jammu	-	215	300
29.	Jamshedpur		338	28
30.	Kanpur	1200	1100	1600
31.	Kavaratti	-	3	2
32.	Kochi	347	400	15
33.	Kohima	-	13	45
34.	Kolkata	3692	2653	3670
35.	Lucknow	1010	475	1200
36.	Ludhiana	400	735	850
37.	Madurai	370	275	450
38.	Meerut	-	490	52
39.	Mumbai	5355	5320	6500
40.	Nagpur	443	504	650
41.	Nashik	-	200	350
42.	Panjim	-	32	25
43.	Patna	330	511	220
44.	Pondicherry	-	130	250

Sl. No.	Name of City	* Municipal Solid Waste (Tonnes per day)		
		1999-2000(a)	2004-2005 (b)	2010-11 (c)
45.	Port Blair	-	76	45
46.	Pune	700	1175	1300
47.	Raipur	-	184	224
48.	Rajkot	-	207	230
49.	Ranchi	-	208	140
50.	Shillong	-	45	97
51.	Shimla	-	39	50
52.	Silvassa	-	16	35
53.	Srinagar	-	428	550
54.	Surat	900	1000	1200
55.	Thiruvanandapuram	-	171	250
56.	Vadodara	400	357	600
57.	Varanasi	412	425	450
58.	Vijayawada	-	374	600
59.	Vishakhapatnam	300	584	334
	Total MSW	30058	39031	50592

** Municipal Solid Waste Study conducted by CPCB through;*
a) EPTRI (1999-2000); b) NEERI-Nagpur (2004-2005); c) CIPET during 2010-11

Table D-4 Disposed of Waste: State-wise generation, collection and treatment [as in February 2016, CPCB (2014-2015) report]

Sl. No.	States &UT	Generated (TPD)	Collected (TPD)	Treated (TPD)	Landfilled (TPD)
1	Andaman & Nicobar	70	70	05	
2	Andhra Pradesh	4760	4287	6402	
3	Arunachal Pradesh	116	70.5	0	
4	Assam	650	350	0	
5	Bihar	1670	-	-	
6	Chandigarh	370	360	250	
7	Chhattisgarh	1896	1704	168	
8	Daman Diu & Dadra	85	85	Nil	
9	Delhi	8370	8300	3240	
10	Goa	450	400	182	
11	Gujarat	9988	9882	2644	
12	Haryana	3103	3103	188	
13	Himachal Pradesh	276	207	125	150
14	Jammu & Kashmir	1792	1322	320	375
15	Jharkhand	3570	3570	65	
16	Karnataka	8697	7288	3000	
17	Kerala	1339	655	390	
18	Lakshadweep	21	-	-	
19	Madhya Pradesh	6678	4351	-	
20	Maharashtra	22,570	22,570	5,927	
21	Manipur	176	125	-	
22	Meghalaya	208	175	55	122
23	Mizoram	552	276	Nil	
24	Nagaland	344	193	-	
25	Orissa	2374	2167	30	

Sl. No.	States &UT	Generated (TPD)	Collected (TPD)	Treated (TPD)	Landfilled (TPD)
26	Puducherry	495	485	Nil	
27	Punjab	4105	3853	350	
28	Rajasthan	5037	2491	490	
29	Sikkim	49	49	0.3	
30	Tamil Nadu	14500	14234	1607	
31	Tripura	415	368	250	
32	Telengana	6740	6369	3016	3353
33	Uttar Pradesh	19180	19180	5197	
34	Uttrakhand	918	918	Nil	
35	West Bengal	9500	8075	851	515
	Total	**1,41,064**	**1,27,531 (90%)**	**34,752 (27%)**	**4,515**

Data of Annual Report 2013-14 & 2014-15

Table D-5 Waste generation and Future Predictions until 2041

Year	Population in billion as per Census Report	Kg Per Capita Solid Wastes	Total Solid Wastes generation as per CPCB Reports (Million Tonnes/year)
2001	1.072	0.439	31.63
2011	1.247	0.498	47.00
2014	1.294	0.398	51.49
Calculated Projected figures			
2021	1.345	0.569	71.15
2031	1.463	0.649	107.01
2036	1.518	0.693	131.24
2041	1.559	0.741	160.96

Source: Prepared by author

Table D-6 Generation of Municipal Solid Waste (MSW) in Class-I cities (total) and state average per capita MSW generation in selected states in 1999

SI. No.	Name of the State/Union Territory	Estimated MSW (tonnes/day)	Per capita generation (gm/day)
1.	Andhra Pradesh	4,652.20	364
2.	Assam	199.64	223
3.	Bihar and Jharkhand	1,833.96	280
4.	Gujarat	4,718.57	451
5.	Haryana	772.52	276
6.	Himachal Pradesh	43.40	All
7.	Karnataka	3,866.32	376
8.	Kerala	1,512.80	393
9.	Madhya Pradesh and Chhattisgarh	2,773.88	316
10.	Maharashtra	10,650.40	378
11.	Manipur	49.60	201
12.	Meghalaya	43.40	157
13	Mizoram	57.64	296
14.	Orissa	801.04	366

SI. No.	Name of the State/Union Territory	Estimated MSW (tonnes/day)	Per capita generation (gm/day)
15.	Punjab	1,241.24	312
16.	Rajasthan	2,192.32	355
17.	Tamil Nadu	6,226.04	467
18.	Tripura	40.92	210
19.	Uttar Pradesh and Uttaranchal	6,838.60	381
20.	West Bengal	5,797.60	321
21.	Chandigarh	248.00	397
22.	Delhi	6,000.00	475
23.	Pondicherry	74.40	295
	Total	**55011.85**	

Source: Report of CPCB on "Status of compliance by CPCB with MSW (Management and Handling) Rules, 2000"

Waste Composition

Studies conducted shows that the waste composition has changed rapidly during 1996 - 2011 and the proportion of high calorific value waste is increasing that has been reflected in the *Planning Commission Report 2014, Govt. of India*. Table D-7 shows that there is significant increase in paper and plastic waste whereas the quantity of insert has come down. This calls for serious effort to utilize compostable as well as burnable waste, adopting 3R concepts for increasing resource utilisation by various methods, namely, reusing, recycling, composting, biomethanation, waste-to-energy etc.

Table D-7 Change in Composition of Municipal Solid Waste across the country

Year	Composition (%)							
	Biodegradable	Paper	Plastics / Rubber	Metal	Glass	Rags	Others	Inerts
1996	42.21	3.63	0.60	0.49	0.60	nil	nil	45.13
2005	47.43	8.13	9.22	0.50	1.01	4.49	4.016	25.16
2011	42.51	9.63	10.11	0.63	0.96	nil	nil	17.00

Sources: Planning Commission Report 2014, Govt. of India

Characterization of wastes is necessary to know changing trends in composition of wastes. Based on the composition / Characterization of wastes, appropriate selection of waste processing technologies could be made. Table D-8 shows the characteristics of Municipal Solid Waste in 59 cities in India that governs the recycling rate.

II. Overall Recycling Rate and Target (%) and Recycling Rate of Individual Components of MSW (Primary Indicator)

There are no targets prescribed in India for recycling of any specific items. Informal rag picking is prominent. The recyclable wastes continue to be low in Indian waste stream primarily due to diversion by rag pickers. On an average, the recyclables in the MSW from residential areas consist of plastic bags (3.1 to 4.8%), soiled newspaper (1.7 to 3.9%), corrugated boxes (1.4 to 2.5%), textiles (1.3 to 2.6%), plastic containers and milk bags (0.8 to 1.9%). Glass, metal, rubber and leather components in the waste are very low in the range of 0.1 to 0.9%.

Newspaper, cardboard, thicker plastics bags, and metals are collected from door to door or community bins. The waste collectors spend perhaps 30-50% of their time sorting saleable materials from the refuse. Communities of 25to 100 families live on or near several dump sites, depending for their livelihood on scavenging. All of these people sell to middle men who often perform some simple sorting and cleaning of the recycled materials. The middlemen sell to wholesalers and hence back to primary industries. Some key factors that affect the potential for resource recovery are the market for the separated material, its purity, its quantity and its location. The costs of storage and transport are major factors that decide the economic potential for resource recovery. On the other hand, there are organized system of segregation of wastes, namely, glass, plastics, metals, textiles, wood, papers, electrical/ electronic gadgets etc in several urban local bodies (ULB)s and recycle the waste appropriately by the primary industries. In India recycling initiatives through both the informal system by rag pickers and formal system by the ULBs are carried out and reached a level of 27% recycling as in 2016.

Table D-8 Recycling rate: Characteristics of Municipal Solid Waste in 59 cities in India

Sl. No.	Name of City	Compostables (%)	Recyclables (%)	C/N Ratio	HCV* (kcal/Kg)	Moisture (%)
1	Kavarati	46.01	27.20	18.04	2242	25
2	Gangtok	46.52	16.48	25.61	1234	44
3	Itanagar	52.02	20.57	17.68	3414	50
4	Daman	29.60	22.02	22.34	2588	53
5	Silvassa	71.67	13.97	35.24	1281	42
6	Panjim	61.75	17.44	23.77	2211	47
7	Kohima	57.48	22.67	30.87	2844	65
8	Port Blair	48.25	27.66	35.88	1474	63
9	Shillong	62.54	17.27	28.86	2736	63
10	Simla	43.02	36.64	23.76	2572	60
11	Agartala	58.57	13.68	30.02	2427	60
12	Gandhinagar	34.30	13.20	36.05	698	24
13	Dhanbad	46.93	16.16	18.22	591	50
14	Pondicherry	49.96	24.29	36.86	1846	54
15	Imphal	60.00	18.51	22.34	3766	40
16	Aizwal	54.24	20.97	27.45	3766	43
17	Jammu	51.51	21.08	26.79	1782	40
18	Dehradun	51.37	19.58	25.90	2445	60
19	Asansol	50.33	14.21	14.08	1156	54
20	Kochi	57.34	19.36	18.22	591	50
21	Raipur	51.40	16.31	223.50	1273	29
22	Bhubaneswar	49.81	12.69	20.57	742	59

Sl. No.	Name of City	Compostables (%)	Recyclables (%)	C/N Ratio	HCV* (kcal/Kg)	Moisture (%)
23	Tiruvanan-	72.96	14.36	35.19	2378	60
24	Chandigarh	57.18	10.91	20.52	1408	64
25	Guwahati	53.69	23.28	17.71	1519	61
26	Ranchi	51.49	9.86	20.23	1060	49
27	Vijaywada	59.43	17.40	33.90	1910	46
28	Srinagar	6177	17.76	22.46	1264	61
29	Madurai	55.32	17.25	32.69	1813	46
30	Coimbatore	50.06	15.52	45.83	2381	54
31	Jabalpur	58.07	16.61	28.2	2051	35
32	Amritsar	65.02	13.94	30.69	1836	61
33	Rajko	41.50	11.20	52.56	687	17
34	Allahabad	35.49	19.22	19.00	1180	18
35	Visakhapatnam	45.96	24.20	41.70	1602	53
36	Faridabad	42.06	23.31	18.58	1319	34
37	Meerut	54.54	10.96	19.24	1089	32
38	Nasik	39.52	25.11	37.20	2762	62
39	Varanasi	45.18	17.23	19.40	804	44
40	Jamshedpur	43.36	15.69	19.69	1009	48
41	Agra	46.38	15.79	21.56	520	28
42	Vadodara	47.43	14.50	40.34	1781	25
43	Patna	51.96	12.57	18.62	819	36
44	Ludhiana	49.80	19.32	52.17	2559	65
45	Bhopal	52.44	22.33	21.58	1421	43
46	Indore	48.97	12.57	29.30	1437	31
47	Nagpur	47.41	15.53	26.37	2632	41
48	Lucknow	47.41	15.53	21.41	1557	60
49	Jaipur	45.50	12.10	43.29	834	21
50	Surat	56.87	11.21	42.16	990	51
51	Pune	62.44	16.66	35.54	2531	63
52	Kanpur	47.52	11.93	27.64	1571	46
53	Ahemdabad	40.81	11.65	29.64	1180	32
54	Hyderabad	54.20	21.60	25.90	1969	46
55	Bangalore	51.84	22.43	35.12	2386	55
56	Chennai	41.34	16.34	29.25	2594	47
57	Kolkata	50.56	11.48	31.81	1201	46
58	Delhi	54.42	15.52	34.87	1802	49
59	Greater Mumbai	62.44	16.66	39.04	1786	54

Source: CPCB report on management of municipal solid waste, 2012

III. 3R Indicators in Industrial and Hazardous Waste

The rate of generation of hazardous wastes in India was 7.467 million tonnes/year as in 2016, 6.7 million tones/year as in 2009 and 7.24 million tones/year as in the year 2000 (CPCB Report, 2016, 2009 and 2000). It is generated by various industrial and anthropogenic activities mainly from mining, tailings from pesticide based agricultural practices, industrial processes of textile, pesticides, tannery, petrochemicals, pharmaceuticals, paints, oil refineries and petroleum processing, fertilizers, asbestos, caustic soda and in production of many chemicals. The Rules related to hazardous waste management (MoEF&CC, 2016 b) establish the responsibility for the safe and environmentally sound handling of hazardous waste by any 'occupier' of hazardous waste. An occupier is a person who has under his charge, any plant or factory producing hazardous waste or who holds hazardous waste for the purpose of storage, processing or disposal. Waste 'Recycling' is defined as reclamation or reprocessing of hazardous waste in an environmentally sound manner for the original purpose or for other purposes. Waste 'reuse' means the use of a hazardous waste for a purpose of its original use or other use.

Common Treatment, Storage and Disposal Facilities (TSDF) are developed for the disposal of land disposable HW at 22 different places in 10 States, namely, Gujarat (7 Nos.), Maharashtra (4 Nos.), Uttar Pradesh (3Nos.), Andhra Pradesh (2 Nos.), Himachal Pradesh (1 No.), Madhya Pradesh (1 No.), Punjab (1 No.), Rajasthan (1 No.),Tamil Nadu (1 No.), and West Bengal (1 No.). Total waste handling capacities (disposal capacity) of these facilities, is 1.5,00,568 million tones/year which is much less than the present generation of 27,28,326 MTA of land-disposable HW. The deficit of TSDF capacity is 1.2,27,758 million tones/year. It is obvious that additional TSDFs with waste handling capacities to the tune of 15,00,000 million tones/year or so must be developed to accommodate the present and future quantities of land disposable HW.

Utilization of hazardous waste as co-processing in cement kilns or in other applications as a supplementary resource or for energy recovery or after processing have very well been initiated in the country. The guidelines for co-processing of hazardous wastes in cement plants have also been prepared by GOI. By integrating co-processing and treatment of wastes in energy and resource rich industry, the country can forego or significantly reduce investments in expensive incinerators, save non-renewal fossil fuels and raw material, reduce green-house gases, increase waste treatment capacity, reduce the impacts of such hazardous wastes and also reduction in land fill requirements.

In order to ensure safe storage, treatment and disposal of hazardous wastes in an environmentally sound manner without causing adverse effect to environment and human health, Govt. of India notified, the Hazardous Wastes (Management and Handling) Rules, in the year 1989 under the Environment (Protection) Act, 1986 and these rules were amended from time to time and have recently been revamped with notification of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. The status of generation and management of hazardous waste in the country as in 2000, 2009 and 2016 is given in Table D-9. The Indian industrial sector generates an estimated 100 million tonnes/year of non-hazardous solid wastes, with coal ash from thermal power stations accounting for more than 70 million tonnes/year. It is obvious that the recyclable portion of HW is in the range of 49.55 % and is more than other two categories. The land disposable portion and incinerable portion are in the tune of 43.78% and 6.67% respectively.

Table D-9 The status of generation and management of hazardous waste in the country as in 2000, 2009 and 2016.

Description	Status in July 2016 in Million Tonnes Per Annum	Status in 2009 in Million Tonnes Per Annum	Status in 2000 in Million Tonnes Per Annum
No of Hazardous Waste generating industries	43,938 nos.	36,165 nos	12,584 nos.
Total generation of Hazardous Waste	7.467	6.232507	7.243,750
Landfillable HW waste	3.416	2.728326 (43.78 %)	5.250,173
Incinerable waste	0.695	0.415,794 (6.67 %)	0.118,941
Recyclable waste	3.356	0.3088,387 (49.55 %)	1.429,281
Sources	CPCB Bulletin Vol.- I, July 2016, Govt. of India	National Inventory of Hazardous Wastes Generating Industries & Hazardous Waste Management in India, CPCB, 2009	Report of MoEF 2000

As per the Rule 11 of the Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008, hazardous wastes could be utilised by the units as a supplementary resource or for energy recovery, or after processing shall be carried out by the units only after obtaining approval from the Central Pollution Control Board. Rule 11 provision of the earlier rules have been modified with Rule 9 in the revamped Rules notified in 2016, which has provisions for issuance of such permissions by SPCBs only for those hazardous wastes for which standard operating procedures or guidelines have been provided by the Central Pollution Control Board. CPCB had issued Guidelines on Co-processing of Hazardous Waste in Cement/ Power/Steel Industry in the year 2010 and Standard Operating Procedure for Processing the Proposals for Utilization of Hazardous Waste under Rule 11 of the Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008 were published in 2015.

Fiftyfour number of cement plants has been granted permission for co-processing. Around 0,176 million tonnes of hazardous waste was co-processed in cement industry during 2014-15.Permission has been granted for utilization of 47 types of hazardous waste under Rule 11 of HW (MH& TBM) Rules 2008 and four types of hazardous waste for co-processing. Co-processing is an effective way for utilization/disposal of hazardous waste in cement kiln, a specific norms “Guidelines on Co-processing in Cement/Power/Steel Industry” has been enacted by CPCB to regulate co-processing of waste both industrial and hazardous waste stream. All the waste cannot be used for co-processing, keeping in view the environment, health, safety and operational concern. The wastes listed below are normally not recommended for co-processing till otherwise proved/evidenced for: Biomedical waste, Asbestos containing waste, Electronic scrap, Entire batteries, Explosives, Corrosives, Mineral acid wastes, Radioactive Wastes, Unsorted municipal garbage.

Import and export (trans-boundary movement) of hazardous and other wastes will be directed by the Ministry of Environment, Forest and Climate Change. No import of the hazardous and other wastes from any country to India for disposal shall be permitted. The import of hazardous and other wastes from any country shall be permitted only for recycling, recovery, reuse and utilization including co-processing. Any occupier intending to export waste has to make an application with insurance cover to the Ministry of Environment, Forest and Climate Change for the proposed trans-boundary movement of the hazardous and other wastes together with the prior informed consent in writing from the importing country in respect of wastes.

Treatment, storage and disposal facility for hazardous and other wastes should be developed by the state government, occupier and operator of a facility or any association of occupiers as per the guidelines issued by CPCB and SPCB from time to time. Packaging and labeling of the waste should be done in a manner suitable for safe handling, storage and transport as per the guidelines issued by the Central Pollution Control Board from time to time. The transport of the hazardous and other waste shall be in accordance with the provisions of these rules and the rules made by the Central Government under the Motor Vehicles Act, 1988 and the guidelines issued by the Central Pollution Control Board from time to time in this regard. The occupier handling hazardous or other wastes and operator of disposal facility shall maintain records of such operations. The occupier, importer or exporter and operator of the disposal facility shall be liable for all damages caused to the environment or third party due to improper handling and management of the hazardous and other waste. Major Hazardous Waste Generating States in India is shown in Table D-10.

Table D-10 Major Hazardous Waste Generating States in India

Name of State	Quantity of Hazardous Waste generation (MTA)			Total MTA
	Landfillable	Incinerable	Recyclable	
Andhra Pradesh	211,442	31,660	313,217	556,319
Chhattisgarh	5,277	6,897	283,213	295,387
Gujarat	1,107,128	108,622	577,037	1,792,787
Jharkhand	23,135	9,813	204,236	237,184
Maharashtra	568,135	152,791	847,442	1,568,368
Punjab	13,601	14,831	89,481	117,913
Rajasthan	165,107	23,025	84,739	272,871
Tamil Nadu	157,909	11,145	89,593	258,647
West Bengal	120,598	12,583	26,597	259,777

Source: National Inventory of Hazardous Wastes Generating Industries & Hazardous Waste Management in India, CPCB, February 2009

Gujarat, Maharashtra and Andhra Pradesh are the top three HW generating States. The HW generation figures of Karnataka, Haryana, Delhi and Bihar appear to be on lower side. Frequency distribution of the HW generation data of 369 districts / regions received from SPCBs / PCCs reveals the fact that 230 districts are generating HW in the range 0-2000 tonnes per annum while 108 districts generate in the range of 2,001-50,000 tonnes per annum. 31 districts are more critical which are producing the HW in the range 50,001-467,100 tonnes per annum. Among the top 31 districts as mentioned above, 10 districts belong to Maharashtra, 8 districts to Gujarat, 5 districts to Andhra Pradesh and 3 districts come from Chhattisgarh. Of the remaining 5, one each belongs to Jharkhand, West Bengal, Rajasthan, Madhya Pradesh and Dadra & Nagar Haveli.

The co-processing of waste is sought after as one of the most sustainable way of disposing hazardous waste because of its property of utilizing the same and recovering energy and substituting conventional raw materials as alternative fuels and raw materials (AFR). There is a high economical gain and environmental sustainability achievable in term of using AFR. The cement production process is highly suitable of treating industrial waste and in some cases also enhances the product property by disposing industrial waste. The co-processing of industrial waste is an effective methodology for CO_2 mitigation as it reduces the carbon emission by reducing the use of virgin material. The process is highly sustainable in number of countries but still lacks full scale implementation in India due to number of supply chain constraints which needs proper addressing. The major constraints are as coined by number of literature and also revealed by the case studies are availability of waste, transportation and storage, installation requirement-technological aspect, composition of the waste, quality of clinker, emission factors and government support (Baidya and Ghosh, 2016). The analysis were carried out on critical chemical constituents present in the various waste streams utilizing the 22 different co-processing trials, which were declared as approved by CPCB, was compiled by reviewing the results of the trial (Parlikar, Baidya and Ghosh, 2016). The details of these trials are enclosed in Table D-11.

Table D-11 Details of co-processing of hazardous waste trial in cement kilns in India

Sl. No.	Cement Plant	Waste stream name	HW Waste Category	Trial Date	Clinker Production rate (TPD)	Co-processing rate (TPD)
1	WADI	Paint sludge	21.9	April, 2008	3,950.0	12.0
2	WADI	Chemical sludge	12.9	April, 2008	3,950.0	12.0
3	WADI	Spent carbon	34.2	July, 2008	3,950.0	19.2
4	WADI	N Butanol	Schedule II Class D4	July, 2008	3,950.0	7.2
5	WADI	Benzofuran	28.1	March, 2012	3,600.0	1.2
6	WADI	Chemical sludge from ETP	29.2	March, 2012	3,800.0	6.2
7	WADI	Mixed Waste of 2 streams (ETP Sludge & Waste Tooth Paste)	34.3 & 28.3	Feb, 2013	3,624.0	10.8
8	Madukkarai	Phosphate sludge	12.5	June, 2008	2,400.0	3.0
9	Madukkarai	Chemical ETP sludge	12.9	June, 2008	2,400.0	12.0
10	Madukkarai	Oily rags	35.1	Dec, 2008	2,400.0	1.0
11	Madukkarai	Process Waste (2CB Residue)	29.1	Aug, 2012	2,400.0	6.9
12	Madukkarai	Waste mix of 6 waste streams (Sludge from process, filters &filter materials)	23.1 & 35.1	Feb, 2012	2,400.0	0.014
13	Kymore	Poly residue	36.4	May, 2010	4,500.0	20.6
14	Kymore	ETP sludge	34.3	Jan-Feb, 2012	4,500.0	15.1

Sl. No.	Cement Plant	Waste stream name	HW Waste Category	Trial Date	Clinker Production rate (TPD)	Co-processing rate (TPD)
15	Kymore	ETP Sludge	34.3	June- July, 2012	4,520.0	9.0
16	Kymore	Mixed Waste of 2 streams (Process Residue & Spent Carbon)	28.1 & 28.2	May-June, 2013	4,500.0	9.6
17	Lakheri	Mixed waste of 3 streams (Grinding Waste, Oil soaked cloth, ETP Sludge)	5.2 & 34.3	Feb - March, 2011	3,100.0	6.5
18	Lakheri	Mixed waste of 2 streams (Organic Plating Sludge & Dyeing Sludge)	12.8 & 26.1	Nov, 2011	3,100.0	12.0
19	Jamul	Acid tar sludge (ATS)	13.3	Jan, 2012	1,200.0	7.2
20	Gagal	ETP Sludge	34.3	Oct, 2012	4,500.0	19.2
21	Chaibasa	Spent catalyst	28.0	March, 2011	4,000.0	19.2
22	Chaibasa	Incineration ash	36.2	April, 2011	4,000.0	13.8

Source: Parlikar, Baidya and Ghosh, 2016

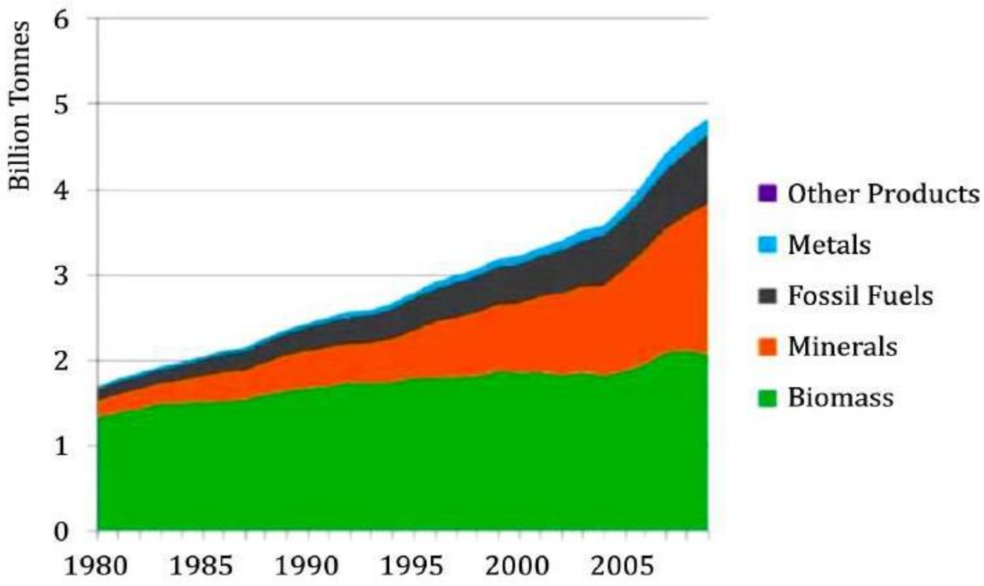
III. Indicators based on macro-level material flows

Material Flow Analysis/Accounting (MFA) is one of the analytical tools that make it possible to monitor countries' resource consumption trend and efficiency in resource use at the macro level. Such indicator can show image of industrial structure and material balance of the country. The macro level indicators are as follows.

- Ratio of virgin materials to total material inputs in the production process.
- Ratio of actual to potential recycled materials
- Ratio of renewable to fossil fuel sources.
- Economic output per unit of material/energy input
- Waste disposal cost per economic output

India is facing increased urbanisation, concomitant with a growing population. Indian cities are already home to about 350 million people, and by 2030, there will be an estimated 590 million people living in cities. Cities, which accounted for around 58% of India's GDP in 2008, will account for nearly 70% of GDP by 2030. However, compared to other BRIC nations, India had a relatively low urban population (31%) in 2010; and is therefore witnessing a much faster rate of urbanisation that is expected to continue till 2050 by which time a majority of India's population is expected to live in cities (McKinsey Global Institute, 2010).Increasing urbanisation creates huge demand for housing, infrastructure and other goods and services. Per capita consumption of materials in India is still low compared to the rest of the world. With an average of 4.2 tonnes per capita, India ranked 151 out of 193 countries in the world in 2009, consuming less than half of the global average of around 10 tonnes. In comparison, in the same year, average resource consumption per capita in

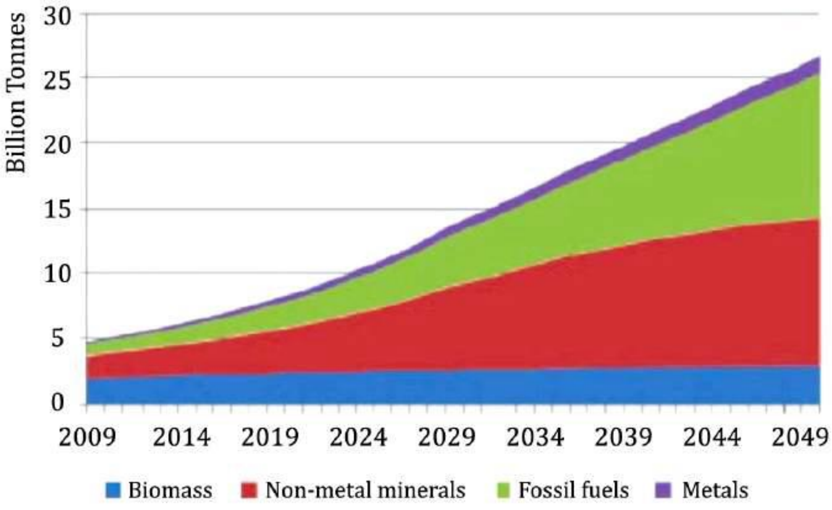
OECD countries was about 15.7 tonnes, while it was around 3.5 tonnes in the least developed countries (Dittrich, 2012). However, due to its large population, India's resource consumption is quite high in absolute terms. It also means that at the current rates of economic growth, India's resource demand is likely to increase very rapidly, and meeting that demand may be challenging. In absolute terms, India's material consumption amounted to 4.83 billion tonnes in 2009, compared to 1.7 billion tonnes in 1980 (an increase of 184%) as depicted in Figure D-3.



Source: IGEP, 2013; p. 17

Figure D-3 Absolute consumption of materials in India, 1980-2009

In 2009, India was the third largest consumer of materials in the world after China (with 21.5Billiontonnes) and the USA (with 6.1 billion tonnes). In that year, India accounted for 7.1% of global material consumption while hosting 17% of global population (Dittrich, 2012). India's material consumption in the past few decades exhibits a pattern typical of countries making a transition from an agrarian society to an industrial society, where the consumption of non-renewable materials increases, in particular minerals and metals required for building infrastructure and fossil fuels for energy supply. This is clearly evident from Figure D-4; the absolute consumption of biomass as almost stagnated while the share of renewable resources has declined from 79% in 1980 to 43%in 2009.If current economic trends persist and population grows according to the medium UN scenario, India's material requirements are projected to be nearly 15 billion tonnes by 2030 and little above 25billion tonnes by 2050 (Dittrich, 2012), with the biggest shares in fossil fuels and non-metallic minerals, as depicted in Figure D-4. According to this projection, by 2030, India will consume as much materials as all the OECD countries combined consume today.



Source: IGEP, 2013; p. 21

Figure D-4 Future material consumption in India by category in scenario continuing current dynamic

V. 3R Indicators: Biomass and Bio wastes

Government of India, Ministry of Agriculture do not maintain data of agricultural wastes produced in the country, as the same is not regulated. The Ministry of New and Renewable Energy (MNRE) in association with Indian Institute of Science, Bangalore has estimated that about 500 million tonnes of agricultural and agro-industrial residues are being generated annually both 'on and off-farm' in the country (IARI, 2012). Crop residues are primarily used for livestock feed, soil mulching, bio-gas generation bio-manure/compost, thatching for rural homes, mushroom cultivation, biomass energy production, domestic and industrial fuel etc. Crop residues are also burnt on-farm to clean the field for sowing of next crop, which results in air pollution.

Government of India, Ministry of Agriculture has formulated National Policy for Management of Crop Residue (NPMCR), 2014, for control of burning of crop residue to prevent environmental degradation. NPMCR has been circulated to all the States including Ministry of Environment, Forests & Climate Change (MoEF&CC) for implementation. Accordingly, MoEF&CC has advised all the States to issue an advisory in multimedia mode at State as well as local level to farmers for prevention of burning of crop residues and biomass in fields and also to facilitate diversified use of crop residues as fuel for power plants, production of cellulosic ethanol, paper/board and packing material etc.

About seventy percent of these residues are used as fodder, as fuel for domestic and industrial sectors and for other economic purposes. About 120-150 million tonnes of surplus agro industrial and agriculture residues per year could be surplus for power generation. MNRE is promoting efficient utilization of biomass like agricultural and agro-industrial residues for power generation in the country. Projects based on biomass combustion and biomass co-generation technologies with a total capacity of over 3,700 MW have been set up in the country as on 31st January 2014. This information was given by the Minister of New and Renewable Energy, Government of India in a written reply in the Parliament on 21st February, 2014.(Source:http://pib.nic.in/newsite/PrintRelease.aspx?relid=104199 as viewed on 18th April 2017).

Biomass is a renewable source of energy that can be used in various domestic and commercial applications such as direct heating, electricity generation and production of biofuels (Singh and Gu, 2010).Biomass (Agro waste, crop residues, Garden waste etc.), if sourced in an environmentally and socially sustainable manner represents a vast and largely untapped renewable energy source for India. Current availability of agro waste in India is estimated about 500 million metric tonnes per year. Studies sponsored by Ministry of New and Renewable Energy, Government of India have estimated that around 70% of agro waste is used as organic fertilizer or as fodder but about 120 – 150 (30%) million metric tonnes per annum agro waste (having potential of 18,000 MW) is left unattended or burnt directly by farmers. This apart, about 7,000 MWadditional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them [Source : Biomass Power Cogen, MNRE, February 2014. [Online]. Available: http://mnre.gov.in/schemes/grid-connected/biomass-powercogen. [Accessed April 20, 2017]. The future of India's bioenergy planning programs depends on the agriculture sector, since the contribution of this sector in the country's economy has been recorded as 18% (The World Bank, 2016).Biomass power generation in India is an industry that attracts investments of over 6.00 billion INR every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas. For efficient utilization of biomass, bagasse based cogeneration in sugar mills and biomass power generation have been taken up under biomass power and cogeneration programme (Source: http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/). Biomass power & cogeneration programmes implemented with the main objective of promoting technologies for optimum use of country's biomass resources for grid power generation. Over 530 biomass power and cogeneration projects aggregating to about 7907.4 MW capacity have been installed in the country up to December 2016 for feeding power to the grid (Annual Report, MNRE 2016-17).

Availability of Biomass

Biomass comes from a variety of sources include, namely, Wood from natural forests and woodlands, Forestry plantations, Forestry residues, Agricultural residues such as straw, stover, cane trash and green agricultural wastes, Agro-industrial wastes, such as sugarcane bagasse and rice husk, Animal wastes, Industrial wastes, such as black liquor from paper, manufacturing Sewage, Municipal solid wastes (MSW), and Food wastes (Source: S. K. Ghosh, 2016). Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, saw dust etc. It has been revealed that 10 types of residues are generated during the harvesting and processing of these crops, which can be used for energy production. The classification of crop residues and their respective properties such as residue-to-product ratio (RPR) and lower calorific value (LCV) are also shown in Table D-12 and State-wise accessibility of crop residues in India shown in Table D-13 [(Hiloidhari, et al, 2014); (Singh et al, 2003), (Directorate of Economics and Statistics, Government of India, 2014). In the Table D-12, CC includes Bajra, Maize, Barley, small Millet, Ragi, & Jawar etc.; for Stalks[b], b means Tonnes/ Hectare (average area for year 2012-13 and 2013-14 = 11.83 million/hectare; LCV[c] represents the energy contents of the residue (on dry basis) and RPR[d] is the quantity of residue produced per unit of crop production.

Table D-12 Classification of agricultural residues and their characteristics

Group	Crop	Residue Type	RPR[d] (kg/ kg)	LCV[c] (Mj/kg)
Cereals	Rice	Straw	1.5	15.54
		Husk	0.2	15.54
	Wheat	Stalk	1.5	17.15
		Pod	0.3	17.39
	CC[a]	Stalks	1.3	18.00
SN	Sugarcane	Bagasse	0.33	20
		Top & Leaves	0.05	20
CN	Cotton	Stalks[b]	3.8	17.4
		Husk	1.1	16.7
		Boll Shell	1.1	18.3

Source: Hiloidhari, et al, 2014

Table D-13 State-wise accessibility of crop residues inIndia

State	Crop production (Mt.)					Accessibility of residues (% of gross residue)
	Rice	Wheat	CC	Cotton	SC	
Andhra Pradesh	13.03	--	5.51	7.14	15.36	33
Assam	4.78	0.03	--	--	0.97	41
Bihar	5.51	5.08	2.05	--	13.48	24
Chhattisgarh	6.72	-	0.26	--	--	33
Gujarat	1.62	3.65	2.21	10.95	12.55	39
Haryana	4.00	11.80	1.05	2.55	7.45	48
Himachal Pradesh	--	0.54	0.71	--	--	33
Jammu & Kashmir	--	0.46	0.55	--	--	29
Jharkhand	2.74	0.36	0.53	--	--	31
Karnataka	3.78	0.23	6.72	1.40	35.91	35
Kerala	0.51	--	--	-	--	32
Madhya Pradesh	2.78	13.93	2.43	1.85	3.31	38
Maharashtra	2.95	1.60	6.25	8.52	76.55	37
Odisha	7.58	--	0.33	--	0.94	32
Punjab	11.27	17.04	0.56	2.25	6.31	48
Rajasthan	--	8.92	6.60	1.05	--	24
Tamil Nadu	5.54	--	2.52	0.50	31.76	33
Uttar Pradesh	14.63	30.25	3.46	--	135.16	33
Uttarakhand	--	0.84	0.30	--	6.43	43
West Bengal	15.31	0.95	0.54	--	1.71	29
Others	3.83	0.23	0.47	0.38	2.14	34

Data source: Hiloidhari et al. (2014) and Directorate of Economics and Statistics, Government of India (2014)

It can be observed that the cereal crops have major contribution (of about 68%) in the total residue production in the country followed by sugarcane (of about 18.83%) and cotton (of about 8.135%). Although, the total production of crop residues in the country is of the order of 600 Mt/year, but it may be noted that there is a wide variability in the availability of crop residues within the country. The Uttar Pradesh state produces maximum crop residues (of the order of 133.97 Mt) followed by Maharashtra (62.80 Mt), Punjab (54.63 Mt), Andhra Pradesh (46.93 Mt) and Madhya Pradesh (39.90 Mt). More than half of the total residues are produced in these states. The State-wise surplus fraction of agricultural residue availability (% of gross) in India has been shown in Table D-14 and State-wise total and surplus agricultural residue, power potential and Cumulative Commissioned Biomass Power and Bagasse Cogeneration Projects Grid Connected is shown in Table D-15. Figure D-5 shows the Gross residue availability and estimate from crop production in India has been shown in Figure D-5.

Table D-14 State-wise surplus fraction of agricultural residue availability (% of gross) in India

State	Cereals	Oil-seeds	Sugarcane	Horti-culture	Pulses	Others	Stateavg.
Andhra Pradesh	29	26	40	44	23	38	33
Arunachal Pradesh	27	11	33	25	22	10	21
Assam	25	40	40	45	47	48	41
Bihar	27	32	33	20	23	10	24
Chhattisgarh	29	20	40	25	47	38	33
Goa	26	NA	38	39	NA	70	43
Gujarat	30	25	40	47	53	NA	39
Haryana	34	37	40	NA	40	90	48
Himachal Pradesh	35	17	38	25	35	48	33
Jammu & Kashmir	29	17	40	NA	NA	NA	29
Jharkhand	26	33	40	NA	47	10	31
Karnataka	30	31	38	32	47	33	35
Kerala	30	20	68	38	35	10	32
Madhya Pradesh	28	23	40	25	43	70	38
Maharashtra	28	33	33	43	47	40	37
Manipur	28	21	40	25	NA	NA	29
Meghalaya	26	15	40	20	35	30	28
Mizoram	29	18	40	32	35	48	34
Nagaland	27	16	40	43	35	38	33
Orissa	29	29	33	52	40	10	32
Punjab	34	30	40	NA	47	90	48
Rajasthan	29	18	40	NA	23	10	24
Sikkim	28	22	NA	NA	NA	NA	25
Tamil Nadu	33	19	40	48	30	29	33
Tripura	34	21	40	45	35	38	37
Uttar Pradesh	37	23	38	25	25	48	33
Uttarakhand	32	53	38	NA	55	NA	43
West Bengal	24	20	43	50	29	30	29
National avg.	29	30	39	42	38	38	34

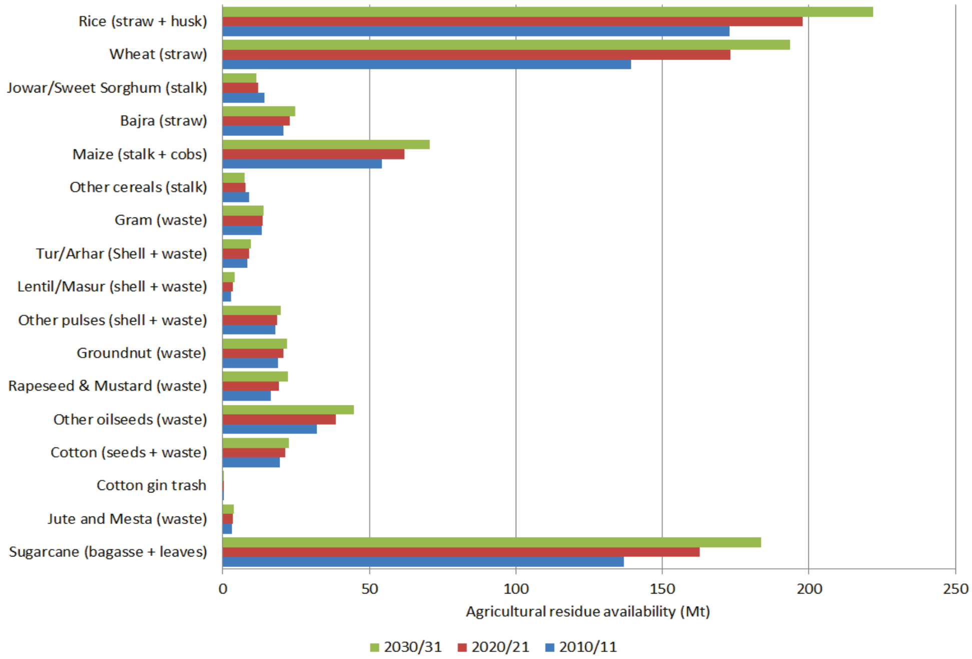
Source: Hiloidhari, et-al 2014

Table D-15 State-wise total and surplus agricultural residue, power potential and Cumulative Commissioned Biomass Power and Bagasse Cogeneration Projects Grid Connected

State	Total residues (Mt.)	Surplus Residues (Mt.)	Power Potential (MW)	Installed Capacity as on 31.12.2016(MW)
Andhra Pradesh	46.93	15.48	2177	378.2
Assam	8.54	3.05	538	-
Bihar	26.28	6.30	861	92.5
Chhattisgarh	11.57	3.82	522	228.5
Gujarat	31.26	12.19	1667	-
Haryana	35.27	16.93	2315	96.4
Himachal Pradesh	1.89	0.62	84	-
Jammu & Kashmir	1.49	0.43	58	-
Jharkhand	5.97	1.85	252	-
Karnataka	32.12	11.24	1537	1401.08

Kerala	0.81	0.25	34	-
Madhya Pradesh	39.90	15.16	2073	92.53
Maharashtra	62.08	22.96	3139	1967.85
Odisha	13.67	4.37	597	50.40
Punjab	54.63	26.22	3585	62
Rajasthan	25.97	6.23	851	119.25
Tamil Nadu	25.37	8.37	1144	889.4
Telengana	NA	NA	NA	158.1
Uttar Pradesh	133.97	44.21	6045	1933.11
Uttarakhand	4.40	1.89	258	72.72
West Bengal	29.07	8.43	1152	300
Others	8.86	3.01	411	-
Total	**600**	**213**	**29,300**	**7907.34**

Source: (Annual Report, MNRE, 2016-17); and (Directorate of Economics and Statistics, Government of India, 2014)



Source: Purohit, 2015

Figure D-5 Gross residue availability and estimate from crop production in India for 2010-11, 2010-21 and 2030-31

The results regarding the surplus biomass potential are presented in Table D-15 which revealed that a total of 213 Mt of the gross biomass is found to be surplus in the country. The agriculture based states like Uttar Pradesh (44.21 Mt), Punjab (26.22 Mt), Maharashtra (22.96 Mt), Haryana (16.93 Mt) and Andhra Pradesh (15.48 Mt) possess high potential for production of surplus biomass, while some of the other states possess lower potential of surplus biomass (with a total potential of 3.01 Mt). The implementation of power projects from biomass have helped in enhancing the livelihood earning of the farmers in the rural areas. It has been observed that the feedstock prices are raised by farmers. The price per ton of different feedstock as fuel is given in Figure D-6.

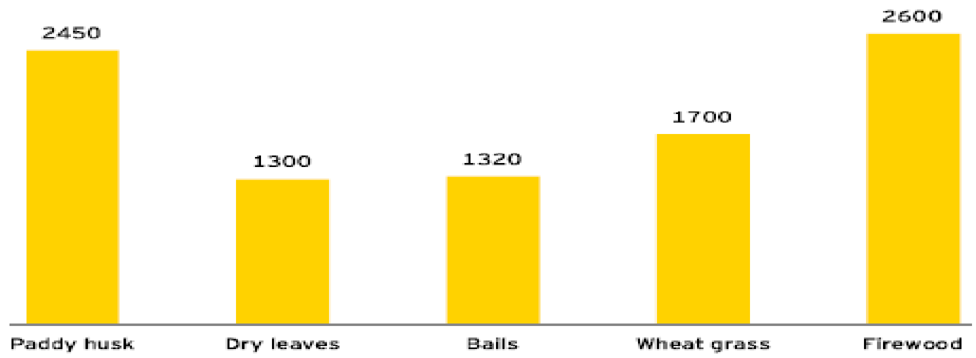
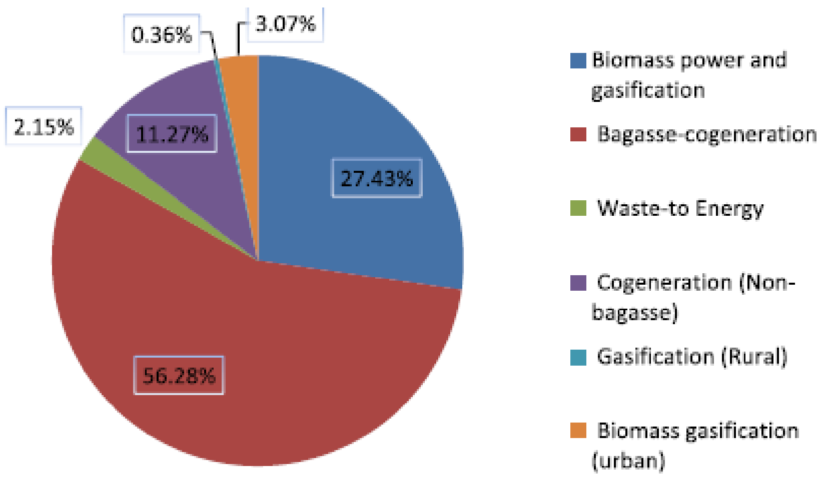


Figure D-6 Feedstock Price as fuel [Source: Socio-Economic and Environment Impacts of Biomass Power Projects (June 2016), A Study Report (as on 01.08.2016)]

Utilisation of Biomass

The utilization of biomass resources at country level biomass (using all residues including rice husk) and cogeneration (using Bagasse) plants are the major source of power generation. Nearly 4.9 GW is produced in India from the utilisation of bio resources, out of which 56.28% is generated from bagasse-cogeneration, 27.43% is generated from biomass power gasification, 11.27% is generated from non-bagasse based cogeneration, 3.07% is from biomass gasification in rural areas, 2.15% from waste–to-energy and only 0.36 from gasification in rural areas as is seen in Figure D-7.

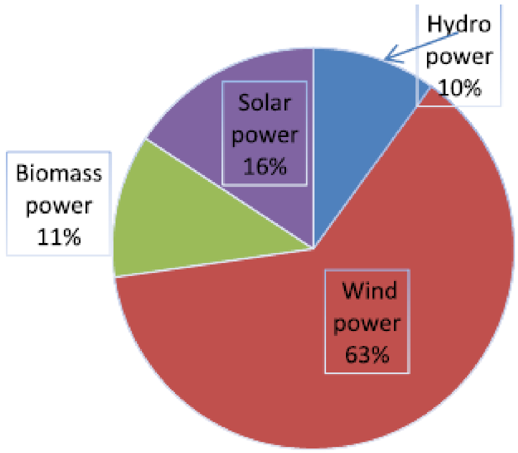


Source : Ministry of New and Renewable Energy, Government of India, 2016

Figure D-7 Source-wise break-up (%) of bioelectricity production (4.9 GW) as on 2016

Currently, bioenergy accounts for about 10% (50 EJ) of world's total primary energy supply [International Energy Agency (IEA), 2012]. Biomass has always been an important energy source for the country considering the benefits it offers. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country’s population depends upon it for its energy needs. The breakup of renewable energy sources (RES) is shown as on 31.12.2015 in MW in Table D-16 and in Table D-17. The source-wise distribution (%) of renewable capacity (as on June

2016) in India is shown in Table D-15. Ministry of New and Renewable Energy has realised the potential and role of biomass energy in the Indian context and hence has initiated a number of programmes for promotion of efficient technologies for its use in various sectors of the economy to ensure derivation of maximum benefits.



Source : Ministry of Power, Government of India, 2016

Figure D-8 Source-wise distribution (%) of renewable capacity (as in June 2016)

The installed capacity of biomass power has been reported by the ministry of new and renewable energy (MNRE) and it has been found that the state-wise installed capacity is insignificant in comparison to the respective power potential of surplus crop residues (Ministry of New and Renewable Energy, Government of India, 2016). Figure D-9 and D-10 shows State-wise and year wise power potential of crop residues and the installed capacity.

Table D-16 Break up of RES all India as on 31.12.2015 in MW.

Small Hydro Power	Wind Power	Bio Power		Solar Power	Total Capacity
		BM Power/ Cogen.	Waste to Energy		
4176.82MW	25088.19MW	4550.55 MW	127.08 MW	4878.87 MW	38821.51 MW

Source: Report of Central Electricity Authority, Power Sector 2016, Ministry of Power, Govt. of India

The contribution of crop residues in the biomass based installed capacity of the country (with total capacity of 4.9 GW) is of the order 83%, which is available for grid supply. The bagasse is the major source of bioenergy that is currently exploited for power production in the country (with a contribution of about 56.28%). This resource is easily available at the sugar mills and involves little handling cost and therefore it is the main source of power production in India. It has been reported that the small scale decentralized power generating systems based on agricultural residues are more efficient and cost effective in Indian scenario (Hiemath et al., 2009).

The biomass combustion is the main technology that is used for generating power in both of these cases (residue and non-residue waste). The off-grid/captive power is mainly generated by non-bagasse 11.27% and 3.07% respectively. These plants are small scale units installed in the remote areas to fulfill local energy demands (by providing off-grid supply to rural areas). The biomass power potential is the highest in the state of Uttar Pradesh (6045 MW) followed by Punjab (3585 MW), Maharashtra (3139 MW) and Haryana (2300 MW), while its value varies significantly within the country. The biomass collection, the supply chain and the moisture contents are the major barriers in India. But, selection of appropriate technology (combustion or gasification) and favourable policies (for use of biomass for energy) can help to resolve these issues.

The Ministry of New and Renewable Energy, Government of India, has been implementing biomass power/co-generation programme since 1990. A total of approximately 500biomass power and cogeneration projects aggregating to 4760 MW capacity have been installed in the country for feeding power to the grid. In addition, around 30 biomass power projects aggregating to about 350 MW are under various stages of implementation. Around 70 Cogeneration projects are under implementation with surplus capacity aggregating to 800MW. States which have taken leadership position in implementation of bagasse cogeneration projects are Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Uttar Pradesh. The leading States for biomass power projects are Andhra Pradesh, Chattisgarh, Maharashtra, Madhya Pradesh, Gujarat and Tamil Nadu. Installed capacity of Andhra Pradesh has been bifurcated in the ratio of 53.89 and 46.11 among Telangana and New Andhra Pradeh respectively. The state-wise/year-wise list of commissioned biomass power/cogeneration projects (As on 01.04.2016) is shown in Table D-17.

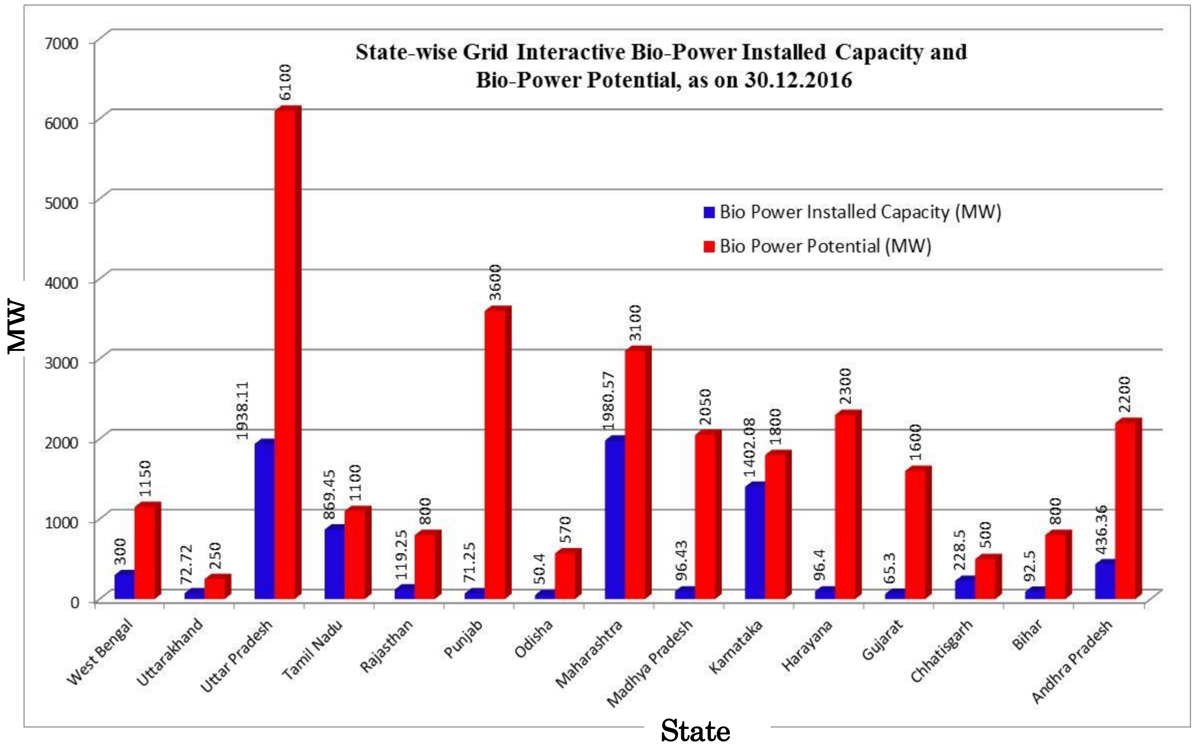
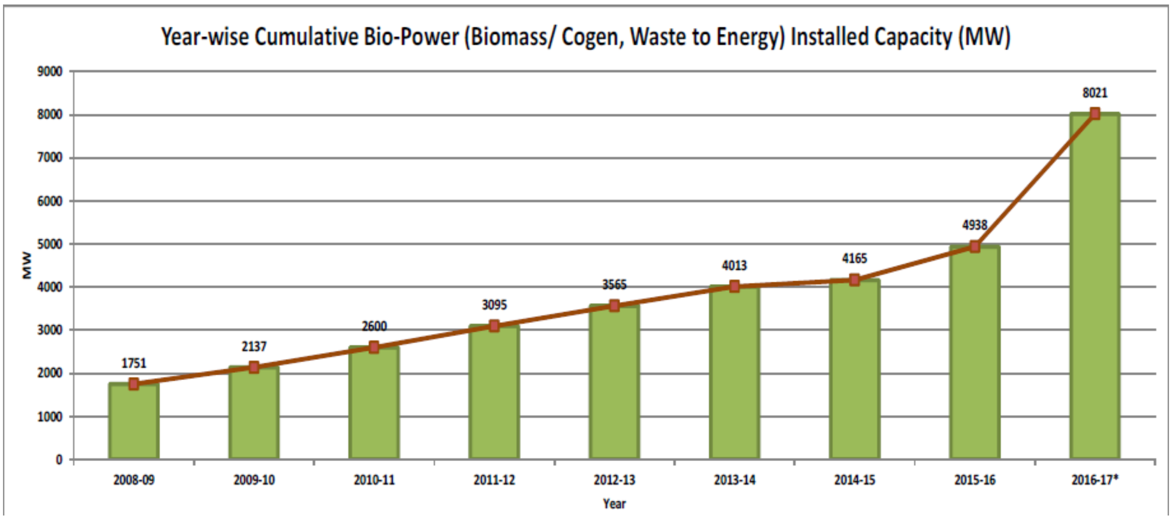


Figure D-9 State-wise power potential of crop residues and the installed capacity



Source: MNRE Annual Report 2016-17;http://mnre.gov.in/file-manager/annual-report/2016-2017/EN/content.html and CSO Data, 2016, Govt. of India

Figure D-10 Year wise power potential of crop residues and the installed capacity

Table D-17 State-wise/year-wise list of commissioned biomass power/cogeneration projects (As on 01.04.2016)

SL. No.	State	Up to 31.03.2012	2012-13	2013-14	2014-15	2015-16 up to 1.4.2016	Total (in MW)
1	Andhra Pradesh	363.25	17.5				380.75
2	Bihar	15.5	27.92				43.42
3	Chattisgarh	249.9		15	15		279.9
4	Gujarat	20.5	10	13.4	12.4		56.3
5	Haryana	35.8	9.5				45.3
6	Karnataka	441.18	50	112	111	158	872.18
7	Madhya Pradesh	8.5	7.5	10	9		35
8	Maharashtra	603.7	151.2	185.5	184	96.38	1220.78
9	Odisha	20					20
10	Punjab	90.5	34	16	15		155.5
11	Rajasthan	83.3	10	8	7		108.3
12	Tamil Nadu	532.7	6	32.6	31.6	39	626.9
13	Uttarakhand	10		20	20	13	50
14	Uttar Pradesh	644.5	132			93.5	842
15	West Bengal	16	10				26
	Total	**3135.33**	465.6	412.5	405	400	**4831.33**

Source: MNRE, GoI, http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/

Biomass Power projects are stimulating the rural economy and impact is spread to the larger community. A financial analysis based on analysis of fixed upfront project cost (assets), fixed operation & maintenance cost and variable fuel cost over the technical operational life time of the biomass power plants (i.e., 20 years) with certain assumptions shows that over the technical operation lifetime of the biomass power project, about 63% of the direct investment/ financing assistance spent on the fuel supply, 13% spent on the O&M and 24% on power plant installation. Figure D-11 shows the biomass power projects life time (20 yrs.) cost estimation (fixed & variable).

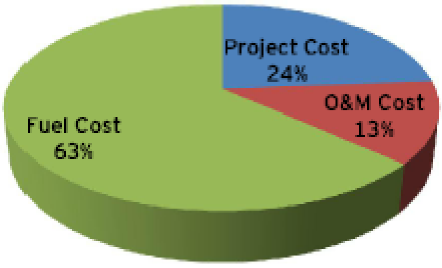
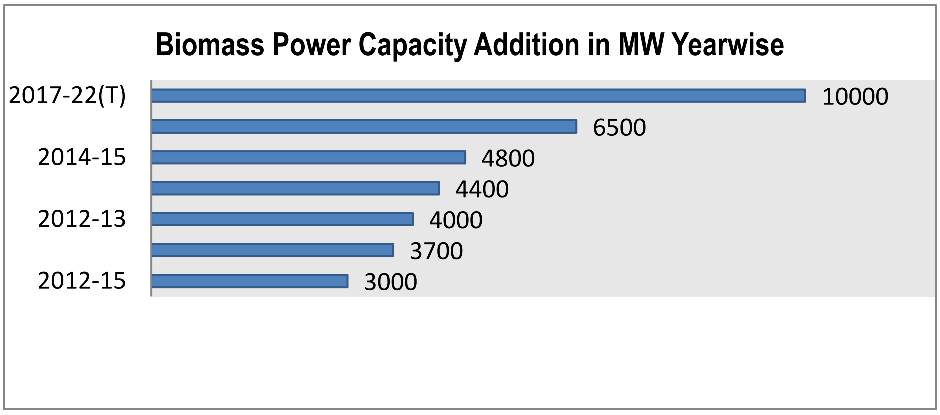
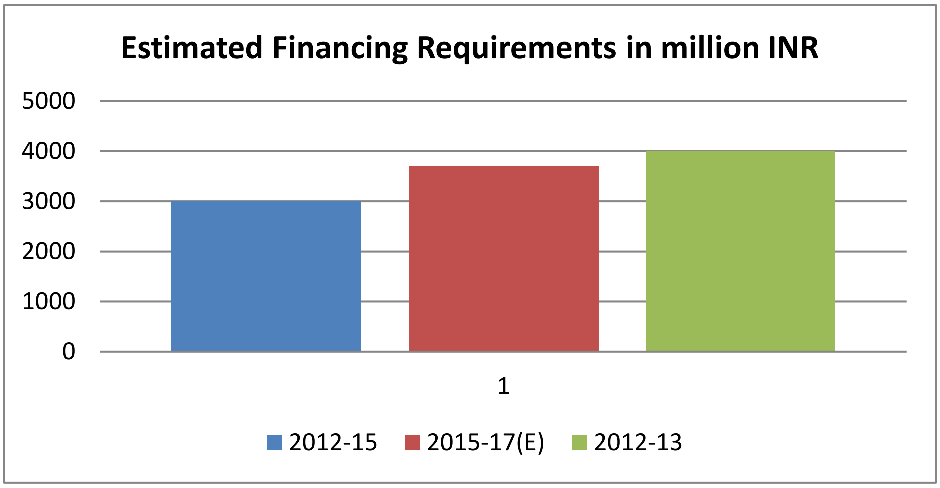


Figure D-11 Biomass power projects life time (20 yrs.) cost estimation (fixed & variable)
(Source: Report on Socio-Economic and Environment Impacts of Biomass Power Projects (June 2016) – (Posted on 01.08.2016), MNRE, GoI).

Subsidies and financial assistance are provided by the state governments indicating keen interest in implementing biomass based energy programs (MNRE, 2015). The government provides 15% of the total cost for small PV Solar plants and for Biomass Power plants, 2.5 million INR/MW in special category states and 2.00 million INR/MW in other states. Accelerated depreciation, concessional customs duty, Excise duty exemption, income tax holiday for 10 years are some of the benefits given to the renewable energy sectors namely, Solar PV, Wind Power and Biomass Power plants. Presently the cost constructing Solar PV is 51.10 to 60.60 million INR/MW, 45.00 to 68.50 million INR/MW for Wind Power and 45.00 to 55.00 million INR/MW for Biomass Power plant excluding the land cost. Benefits to the Tariff, Operating cost and PLF is also provided by the government to encourage the plant operator. Figure D-12 shows Biomass Power Capacity addition Targets (MW) and estimated Finance Assistance requirements from FIs (at base price) 2010-11 to 2017-22 (projected).

The government of India has an ambitious target to achieve the renewable energy capacity of 175 GW by 2022; the sector wise capacity targets include 100 GW for solar (57%); 60 GW for wind (34%); 10 GW for biomass and 5 GW for small hydro power plants. Recently, India has submitted its intended Nationally Determined Contribution (NDC) to the UNFCCC that reinforces the commitment of increasing power generation from renewable energy sources. The ministry of new and renewable energy (MNRE), govt. on India and the Reserve Bank of India (RBI) encouraging the financial institutes to increase their lending portfolios in renewable energy sectors. RBI has inducted the renewable energy in priority sector lending (Circular: FIDD.CO.Plan.BC.54/04.09.01/2014-15 dated 23rd April 2015).





Source : MNRE Report 2015-16

Figure D-12 Biomass Power Capacity addition Targets (MW) and estimated Finance Assistance requirements from FIs (at base price)

VI. Plastic Waste Management and Marine and coastal plastic waste

Plastic industry is making significant contribution to the economic development and growth of various key sectors in the country such as: Automotive, Construction, Electronics, Healthcare, Textiles, Packaging and FMCG etc. Its demand has been growing rapidly at ~10% CAGR to reach 10 MnTPA by FY 2013. 43% plastics produced in India is used in packaging plastics which are. As per industry estimates, 35-40% of the food products produced in India are wasted due to deficient infrastructure and lack of food processing capabilities. Plastics find applications in packaging which protects the longevity and quality of food. This sector in India also offers significant potential for growth leading to increase in demand for plastics.

More than 15,000 tonnes of plastic waste are generated each day, of which 6,000 tonnes remain uncollected and littered, the Minister of State for Environment, Forest and Climate Change, GoI said in a written response to a question in Lok Sabha, CPCB has estimated the generation of 15,342 tonnes of plastic waste in 60 cities of the country, out of which, 9,205 tonnes were reported to be recycled and leaving 6,137 tonnes uncollected and littered as in August 2016. The Plastics Waste Management rules 2016 prescribe two years' time to phase out manufacturing non-recyclable multilayered plastic. The lack of awareness and absence of effective tools to collect back the discarded plastic products including the wrapping material has led to the indiscriminate littering and disposal of plastic waste. The new rules provide for ways and means to minimise plastic waste generation, adoption of extended producer responsibility for collection of waste and sustainable plastic waste management, recycling and utilisation of plastic waste in road construction, energy and oil generation. CPCB has carried out a study in collaboration with CIPET, Ahmedabad on "Quantification and Characterisation of Plastic waste generation in 60 Major Cities (2010-12)"in the country. It is reported that approximately, 3501 TPD of plastic waste (PW) was generated in these cities. The percentage of plastic waste present in the Municipal Solid Waste (MSW) is ranging from 3.10% (Chandigarh) to 12.47% (Surat). (Table D-18). The cities of Delhi, Chennai, Kolkata, Mumbai, Bengaluru, Ahmadabad and Hyderabad are generating maximum quantity of Plastic Waste. No primary or secondary data available on Marine and coastal plastic waste.

Recycling of plastics is one of the foremost steps towards innovation and sustainability in this industry. Currently in India, number of organized recycling units for plastics is ~3,500 along with additional ~4,000 unorganized recycling units. Most of the plastics (PE, PP, PVC, PET, PS,) etc. could be recycled via mechanical route. Whereas, engineering plastics like PBT, SAN and Nylon etc. are recycled by selected recyclers. In India, recycling of plastics is currently 3.6MnTPA and it provides employment to almost 1.6 Million people (0.6 million directly, 1 million indirectly). (Source: FICCI 2014).

The collection & segregation of recyclable waste is one of the key steps in taking this further. Many a times, households and establishments throw the waste on the street or dump it in open without segregating the waste which reduces the quality and at times could make it hazardous. It is essential to save the recyclable waste material from going to the disposal sites and using up landfill space. Salvaging it at source for recycling could make profitable use of such material. This will save national resource and also save the cost and efforts to dispose of such waste. An optimum way to achieve it is by forming a habit of keeping recyclable waste material separate from food waste and other bio-degradable wastes, in a separate bag or bin at the source of waste generation, by having a three-bin system for storage of waste at homes, shops and establishments where the domestic food waste (cooked and uncooked) goes into the Municipal Solid Waste collection system and recyclable waste can be handed over to the waste collectors (rag-pickers) at the doorstep for transporting the same to the recyclers.

Currently, less percentage of plastics produced is used for recycling whereas the potential is much higher. As plastic consumption is expected to grow at more than 10% CAGR for the next 5 years, the scope of recycling of plastics is huge. However the real solution lies in segregation of waste at source and promoting creation of waste management infrastructure coupled with investment in developing recycling centers.

Table D-18 Plastic Waste Generation in Sixty Major Cities of India

S. No.	Name of City	Total Municipal Solid Waste (Tonnes per day)	Plastic Waste (Percentage of Municipal Solid Waste)	Plastic Waste (Tonnes per day)
		2010-11	2010-11	2010-11
1.	Kavaratti	2	12.09	0.24
2.	Dwarka	18	8.08	1.45
3.	Daman	25	4.64	1.16
4.	Panjim	25	4.47	1.12
5.	Gangtok	26	8.95	2.33
6.	Jamshedpur	28	3.36	0.94
7.	Silvassa	35	6.11	2.14
8.	Port Blair	45	10.07	4.53
9.	Kohima	45	5.01	2.26
10.	Shimla	50	4.45	2.23
11.	Meerut	52	6.42	3.34
12.	Gandhinagar	97	4.81	4.66
13.	Shillong	97	5.44	5.27
14.	Itanagar	102	5.35	5.46
15.	Agartala	102	5.71	5.83
16.	Aizwal	107	7.95	8.50
17.	Imphal	120	5.13	6.16
18.	Ranchi	140	5.92	8.29
19.	Kochi	150	6.29	9.43
20.	Dhanbad	150	5.02	7.52
21.	Guwahati	204	5.04	10.27
22.	Asansol	210	6.01	12.62
23.	Dehradun	220	6.67	14.66
24.	Patna	220	5.73	12.60
25.	Raipur	224	10.61	23.76
26.	Rajkot	230	6.93	15.93
27.	Thiruvanandapuram	250	6.02	15.06
28.	Pondicherry	250	10.46	26.15
29.	Chandigarh	264	3.10	8.18
30.	Jammu	300	7.23	21.68
31.	Jaipur	310	5.03	15.58
32.	Vishakhapatnam	334	9.03	30.17
33.	Nashik	350	5.82	20.38
34.	Bhopal	350	6.59	23.08
35.	Allahabad	350	5.39	18.86
36.	Jabalpur	400	5.18	20.70
37.	Bhubaneswar	400	7.98	31.92
38.	Madurai	450	5.06	22.77
39.	Varansi	450	5.76	25.92
40.	Agra	520	7.86	40.89
41.	Srinagar	550	5.12	28.14
42.	Amritsar	550	4.44	24.42
43.	Vadodara	600	4.57	27.41
44.	Vijayawada	600	7.29	43.72
45.	Nagpur	650	7.07	45.96
46.	Coimbatore	700	9.47	66.31
47.	Faridabad	700	11.29	79.03
48.	Indore	720	8.81	63.40
49.	Ludhiana	850	5.96	50.68
50.	Surat	1200	12.47	149.62
51.	Lucknow	1200	5.90	70.84
52.	Pune	1300	7.80	101.35
53.	Kanpur	1600	6.67	106.66
54.	Ahmedabad	2300	10.50	241.50
55.	Kolkata	3670	11.60	425.72
56.	Bangalore	3700	8.48	313.87
57.	Hyderabad	4200	4.75	199.33
58.	Chennai	4500	9.54	429.39
59.	Mumbai	6500	6.28	408.27
60.	Delhi	6800	10.14	689.52
	Total MSW	50592		
	Average PW generation		**6.92**	**3501.00**

Source: Assessment & Quantification of Plastics Waste Generation in Major Cities, CPCB, January, 2015

Indiscriminate littering and non-biodegradability of plastic waste raises several environmental issues; such as choking of drains, making land infertile & on ingestion by cattle lead to death; Burning of plastic generates toxic emissions. Organised/systematic system has been developed by a few concerned municipal authorities for collection, segregation, transportation and disposal of plastics waste. As per estimation the plastic waste generation is 15342 tonnes/day. 14 states/UTs have banned plastics carry-bags. These include-Andaman & Nicobar Islands, Chandigarh, Chhattisgarh, Delhi, Haryana, Himachal Pradesh, Jammu &Kashmir, Karnataka, Lakshadweep, Nagaland, Rajasthan, Sikkim, Tripura, Uttar Pradesh.

The usage of plastic carry bag has been restricted in major pilgrimage centers, tourist places, including hill station and places of historical importance. The minimum thickness of carry bag has been increased to 50 micron from previous 40 micro by the CPCB.

Despite having the Legislations and Guidelines in place, the illegal manufacturing of unauthorized plastic carry-bags $<50\mu$ is going on. Despite Rules for collection, segregation, transportation and disposal of plastic waste, it is going uncollected and littered all over which calls for strict implementation of the Rules in the country. There is also need to develop cost effective alternatives like Textiles, Paper, Jute bags etc. to plastic and plastic carry bags like biodegradable and compostable plastic bags as per Rules PWM Rules, 2016. There is an obvious and urgent need to take a focused and strategic approach towards plastic waste management as well as plastic products management. A tentative Action Plan for Plastics Waste Management to be adopted by concerned Municipal Authorities was made by the CPCB in 2015. In view of deteriorating environmental conditions and illegal manufacturing, sale & use of sub-standard plastic carry bags and indiscriminate littering of plastics waste giving ugly look of the city or town, CPCB initiated actions to be implemented by (vide letter dated 19.12.2014 U/s '5' of Environmental (Protection) Act, 1986) all the Chairmen of SPCBs/PCCs & Secretaries of Department of Urban Development Department, State Government/UTs (I/c Municipal Bodies) for compliance of provisions of the existing rules. The Indicative Action Plan for Plastics Waste Management was released by the CPCB for implementation in all the states by ULBs in Table D-19.

Table D-19 Indicative Action Plan for Plastics Waste Management

Sr No.	Action Points	Time Target	Infrastructure Requirements	Implementing Authority
1.	Setting of Plastics Waste Management System	6 months	Establishment of separate bins at source and Transfer Stations	Municipal Corporation, Nagar Nigam, Council, Gram Panchayat etc.
2.	Collection& Segregation at Source and Transfer Stations (Dhalaos or Bins)	6 months	Engaging skilled SKs or workers for segregation of Plastic Waste	Municipal Corporation, Nagar Nigam, Council, Gram Panchayat etc.
3.	Transportation, Processing or Treatment or Disposal	6months	Engaging Vehicles for transporting PW into Recycling, Road construction or co-processing	Municipal Corporation, Nagar Nigam, Council, Gram Panchayat etc.
4.	Extensive Mass Awareness Programme	Immediate	Mobile Vans, Newspapers, TV Channels, FM radio	Municipal Corporation, Nagar Nigam, Council, Gram Panchayat etc
5.	Engaging Expert MSW & PW Processing Agencies	6 Months	At least 30 years lease be given to such agencies with sufficient fund provisions for O& M	Municipal Corporation, Nagar Nigam, Council, Gram Panchayat etc
6	Strict vigil on open burning	Immediate	Inter-zone vigilance squads be formed to check open burning	Municipal Corporation, Nagar Nigam, Council, Gram Panchayat etc
7.	Restricting use of <40µ thickness plastics carry-bags and permitting compostable material carry-bags conforming or having marking/labelling of IS/ISO:17088	Immediate	Inter-zone vigilance squads be formed with the assistance of SDMs to confiscate <40µ thickness plastics carry- bags. Permit compostable material carry-bags conforming or having marking/labelling of IS/ISO:17088	Municipal Corporation, Nagar Nigam, Council, Gram Panchayat etc and concerned SDMs

Source: CPCB 2015

VII. 3R Indicators in E-waste Management

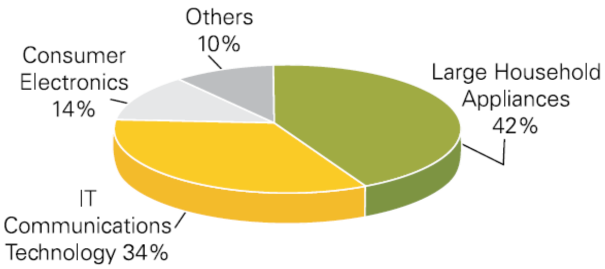
The Ministry of Environment, Forest and Climate Change has revamped the E-Waste Management Rules, 2016 in supersession of the e-waste (Management & Handling) Rules, 2011. The 2016 Rules include Compact Fluorescent Lamp (CFL) and other mercury containing lamps, as well and other such equipment. (Source: CPCB Bulletin Vol. - I, July 2016, Govt. of India). The new rules have been effective from 01-10-2016. These rules are applicable to every producer, consumer or bulk consumer, collection centre, dismantler and recycler of e-waste involved in the manufacture, sale, purchase and processing of electrical and electronic equipment or components specified in schedule – I of these Rules. Two categories of electrical and electronic equipment namely, (i) IT and Telecommunication Equipment and (ii.) Consumer Electricals and Electronics such as TVs, Washing Machines, Refrigerators Air Conditioners including fluorescent and other mercury containing lamps are covered under these Rules. The main feature of these rules is Extended Producer Responsibility (EPR). Target based approach for implementation of EPR has been adopted in the E-Waste (Management) Rules, 2016, which stipulate phase wise collection target to producers for the collection of e-waste, either in number or weight, which shall be 30% of the estimated quantity of waste generation during first two year of implementation of rules followed by 40% during third and fourth years, 50% during fifth and sixth years and 70% during seventh year onwards (Table D-22). The per capita WEEE generation in India is nearly 0.4 kg annually. India generates 1.641 million tonnes of E-waste, whereas only 0.349 million tonnes are collected by formal sectors as per the data in 2014. [(S K Ghosh et al, 2016);(CPCB, 2014); (UNU-IAS SCYCLE, 2015a)].The E-Waste (Management) Rules, 2016 mandate CPCB to prepare guidelines on implementation of E-Waste Rules, which includes specific guidelines for extended producer responsibility, channelisation, collection centres, storage, transportation, environmentally sound dismantling and recycling, refurbishment, and random sampling of EEE for testing of RoHS parameters. In this document all the above guidelines have been compiled except guidelines for random sampling of EEE for testing of RoHS parameters. These guidelines are given in separate sections of this document.

Inventorization of E-waste Generation, Disposal and Recycling

Inventorization of e-waste is an ongoing process and the responsibility rests with respective State Pollution Control Boards. As of December 2016 there were a total of 178 number of registered recyclers and dismantlers having recycling/ dismantling capacity of 2,93,572 MTA for environmentally sound management of E-waste. According to report No. 266 on E-Waste and E-Radiation of the Parliamentary Standing Committee on Science & Technology, Environment & Forests, submitted during July 2015,the 126 number of E-waste recyclers/ dismantlers was inadequate to treat the quantum of nearly 8 lakh tonnes of e-waste generated in the country. There was immediate need to increase the number of dismantlers/ recyclers/ collection centres specially in states generating large quantum of e-waste and the gap between the e-waste generated and the capacity to deal with it should be bridged at the earliest possible. At the same time, a review of the issue highlighted that large amount of e-waste recycling is in informal sector and the quantity of e-waste processed by the registered dismantlers and recycler is only 1,21,381 MTA in the year 2013-2014 against their capacity of 4,55,059 MTA, thus indicating unutilized existing capacity for recycling. To ensure better implementation of management of electronic waste, the e-Waste Management Rules, 2016 has provisions for expanding producers' responsibility by setting up of Producers' Responsibility Organizations and e-waste Exchange, assigning specific responsibility to bulk consumers of electronic products for safe disposal, providing for economic incentives for collection of electronic waste, and other measures to include dedicated responsibility of electronic and electrical product manufacturers for collection and channelizing of electronic waste.

Electrical and electronic waste (e-waste) is one of the fastest growing waste streams in the world. The Committee on subordinate legislation (2016-2017) of 16th Lok Sabha in its 23rd report in August, 2017 noted that during the last decade, there has been an exponential increase in the generation of e-Waste all across the world including India and according to CPCB's estimate, 1,46,800 metric tons (MT) of e-Waste was generated in India in the year 2005 which increased to an estimated 8,00,000 MT by 2012, and 16.4 lakh MT by 2014. As per ASSOCHAM-KPMG study result released in September 2017, the e-waste from old mobiles and computers in India will rise by about 1800 per cent and 500 per cent respectively by 2020 as compared to the levels in the year 2007. Approximately 18 lakh MT of e-waste was discarded in 2016 which is about 12 per cent (%) to the global e-waste production being the fifth largest producer of e-waste in the world and recycles less than two per cent of the total e-waste it produces. Manufacturers' Association for Information Technology's study said that in 2007, a sum of 3,30,000 MT of e-waste was generated annually. In India, due to high rate of refurbishment and reuse and poor collection efficiency of electronic products only a small quantity of e-waste is recycled. At present most of e-waste generated in the country is recycled in the informal sector having small capacities and poor processing technologies contributing significantly to the pollution load and environmental degradation. Some of the e-waste recyclers are engaged in dismantling e-waste for export. There is shortage of proper e-waste recycling facilities in India to do end-to-end recycling. (Sources: Handbook on Procedures for E-Waste Recyclers, GTZ, 2009). E-waste handling is a problem of increasing proportion, especially when crude methods are adopted for recovery of useful components from it. Almost 90 per cent of the E-waste in the country goes to the informal sector and is dismantled and recycled in the remote colonies of the cities that have no awareness of safe disposing methods; thus necessitating a dire need to make people aware (R. Agarwal, 2014). The E-waste (Management and Handling) Rules 2011 are based on EPR (Extended Producer Responsibility) concept. Since the Rules came into force from May 2012, E-waste management infrastructure has slowly been on the rise in India. The implementation of the E-Waste (Management) Rules, 2016 would be a major challenge because of the complexity of the issues and involvement of many stakeholders in the E-waste value chain which includes a large number of people working in the informal (unorganized) sector. Under these rules, the government introduced Extended Producers Responsibility (EPR) which makes producers liable to collect 30 per cent to 70 per cent (over seven years) of the e-waste they produce. The draft E-Waste (Management) Amendment Rules, 2017 has been notified in India on 30th October, 20l7.

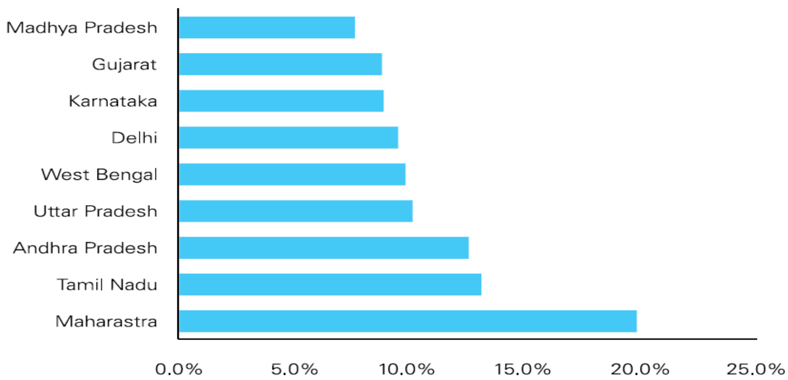
The SPCBs/ PCCs prepared inventory of e- waste in respective States/ UTs. As on 29th December, 2016, there are 178 registered dismantler/recycler in 14 states in India having capacity of 438,086 MT per annum with the maximum 57 in Karnataka and 32 in Maharashtra. One hundred and fifty one (151) Producers have been granted authorisation in 11 States/UTs for managing their EPR. Other SPCBs/PCCs have reported nil authorized producers in their States/UTs. Figure D-13 shows the sources of E-waste in India (% of total E-waste generated), Figure D-14 shows State wise E-waste Generation in India (% of total waste) and Figure D-15 shows the City wise E-waste generation in India (% of total waste).



Source: Manufacturers' Association for Information Technology (MAIT), 2013, TERI

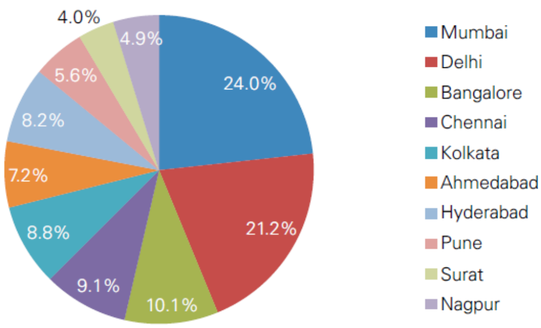
Figure D-13 Sources of E-waste in India (% of total E-waste generated)

Most of the authorized recyclers in the country don't have environmentally sound facility for extraction of precious metals form printed circuit board (PCB) which ultimately either get exported to developed country to recover the precious metal or channelized to informal sector which extract the precious metals using primitive methods (Debnath and Ghosh, 2017). Accordingly, the issue is to be handled by strengthening of regulatory safeguards and formulation of regional development plan for resource recovery. As far as regional development plan for resource recovery is concerned, ministry is coordinating with Department of Electronic and Information Technology on the issue which has already undertaken initiatives such as R&D programme with respect to recycling technology for extraction of precious metals, plastics and glass; up-scaling developed technologies; demonstrations through pilot plants; commercialization of technology transfer etc.



Source: RajyaSabha, 2011

Figure D-14 State wise E-waste Generation in India (% of total waste)



Source: RajyaSabha, India, 2011

Figure D-15 City wise E-waste generation in India (% of total waste)

India is generating e-waste more than 8,00,000 tonnes annually [MoEF, Guidelines, 2008]. The 70% e-waste is being generated by ten states in the country (Rajya Sabha Report, 2011).The obsolete, short lived, damaged, End of life EEEs (Electrical and Electronic Equipment) all together made e-waste a fast growing waste in the country. In India, IT industry has promoted both software and hardware segment and become leader in the world. The growth rate of IT [Information Technology] industry was 42.4% between 1995 to 2000[EMPA, 2006]. The use and dynamism of EEEs for information and telecommunication technology have been enhanced by manufactures and marketing agencies manifolds, resulted a huge infrastructure expansion in the country. The new technology needs new compatible infrastructure replacing the old one in a very short duration of time. Table D-20 shows the Inventory of E-waste generated in India states and union territories in 2010.

Table D-20 Inventory of E-waste generated in India states and union territories in 2010

State / UT	e-waste Generated tonnes per year	State / UT	e-waste Generated tonnes per year
Andaman and Nicobar Islands	92.2	Lakshadweep	7.7
Andhra Pradesh	12780.3	Madhya Pradesh	7800.6
Arunachal Pradesh	131.7	Maharashtra	20270.6
Assam	2176.7	Manipur	231.7
Bihar	3055.6	Meghalaya	211.6
Chandigarh	359.7	Mizoram	79.3
Chhattisgarh	2149.9	Nagaland	145.1
Dadra and Nagar Haveli	29.4	Orissa	2937.8
Daman and Diu	40.8	Puducherry	284.2
Delhi	9729.2	Punjab	6958.5
Goa	427.4	Rajasthan	6326.9
Gujarat	8994.3	Sikkim	78.1
Haryana	4506.9	Tamil Nadu	13486.2
Himachal Pradesh	1595.1	Tripura	378.3
Jammu and Kashmir	1521.5	Uttar Pradesh	10381.1
Jharkhand	2021.6	Uttarakhand	1641.1
Karnataka	9118.7	West Bengal	10059.4
Kerala	6171.8		

Source: The RajyaSabha Report in 2011

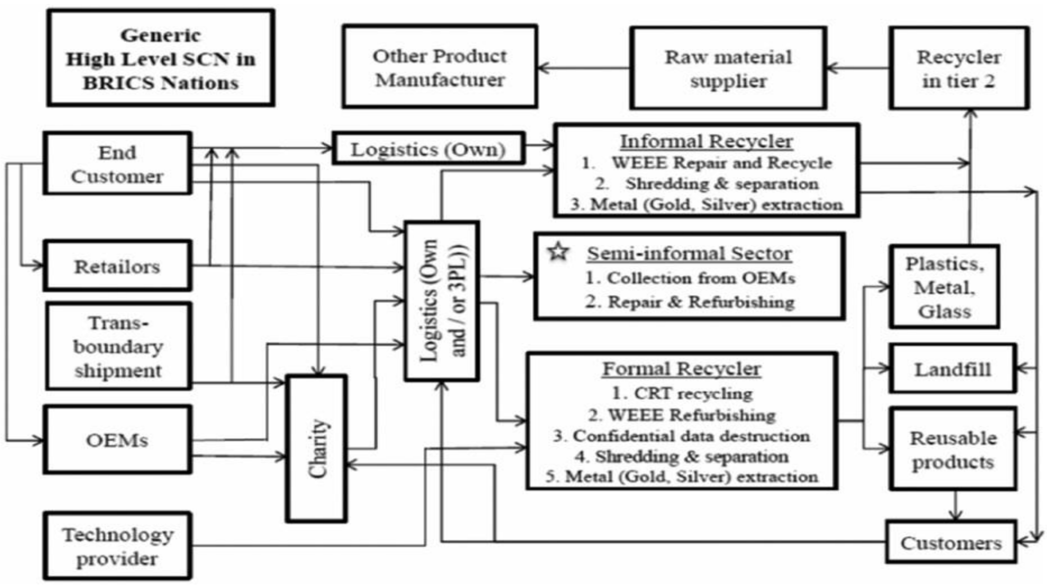
In view of that EEEs in installations have increased manifolds in the country and a huge quantity of e-waste has been generated due to obsolescence. The computers, televisions, servers, music systems, mobile phones, refrigerators, air-conditioners, medical equipment and their respective assemblies and illegal outsourcing are the major contributors of e-waste in the country. The flow of e-waste is very rapid causing threats to the human health, environment due to the presence of toxic and hazardous substances like mercury, lead, cadmium, chromium (VI) [MoEF, Guidelines, 2008] etc. in the components of these e-wasted EEEs. The new rules will help the un-organized sector in scientifically disposing E-waste by creating a safe supply chain and sustain their livelihood by adopting safe method of handling E-waste. Table D-21 shows the E-waste generation in India from 2005 to 2015.

Table D-21 E-waste generation in India between 2005 to 2015

Year	Amount	Sources
2005	0.146 million tonnes	MoEF annual report 2011-12
2012	8 Lakh Tonnes (Predicted)	MoEF annual report 2011-12
2014	1.41 million tonnes	STEP Global Monitor 2015
2015	1.7 million tonnes	CPCB bulletin 2016

Challenges of Managing E-waste in Corporate Sector

Managing end-of-life IT equipment presents a business opportunity for the recycling industry, but must be treated as a business responsibility by the ICT industry. Several proactive steps have been taken in this regard by the ICT sector both at the global level as well as at the national levels. The ICT industry in India—as manufacturers and bulk consumers—should take appropriate steps to ensure that the E-waste generated is managed in an environmentally sound manner.



Source: S K Ghosh,et al, 2016

Figure D-16 Generic high-level WEEE supply chain framework (starting from OEM including reverse SCN) existing in India. CRT: cathode ray tubes; OEMs: original equipment manufacturers; SCN: supply chain network; WEEE: waste electrical and electronic equipment.

The recent environmental laws aimed at products rather than end-of-pipe pollution focus on new product design mandates, substance restrictions, energy efficiency, and take-back mandates. The industry needs to take into account these emerging trends of legislation to identify and manage risks. Some the challenges for the industry are enumerated below: Functioning of EPR (Extended Producers' Responsibility) systems: Identifying the unbranded and counterfeit products, poses a challenge for establishing an effective EPR system. The Generic high-level E-waste supply chain framework starting from OEM including reverse supply chain network existing in India is shown in Figure D-16. Establishing a sustainable supply chain of E-waste is very important for effective implementation of the E-waste (Management) Rules 2016.

Moreover, during product repair, original components often get replaced with those of other brands. Also, unlike the formal E-waste recyclers who meet global standards, the informal E-waste recycling sector has low operating costs and can offer better prices for end-of-life products. The effective functioning of an EPR system is further hampered by the lack of knowhow when it comes to establishing collection systems for recyclables, and establishing good practices for environmentally sound recycling of E-waste. Transparency in downstream of the recycling industry: IT managers are concerned about where their electronic equipment ends up after disposal due to sensitive data loss. Often IT companies seek out sale of their IT scrap—mixed with other scrap—through auction. Alternatively, an asset recovery agency is engaged to handle the IT scrap. In both cases, the IT industry has limited control on the entire downstream flow of hazardous E-waste through their facilities, until it reaches the area of final disposition. The lack of transparency also poses a threat to data security and chance of data-leakage that many organizations fear while discarding hard drives and other data-storage devices.

Limited success of take-back policies: While several companies have initiated take-back schemes, green boxes, and collection centres, these initiatives have met with little or no success. To incentivize the adoption of these schemes, there is a need for the industry to develop partnerships with waste-recycling companies, other waste generators and handlers (paper, plastic, glass, metal, etc.) and the corporate sector.[Sources: {Guidelines on Implementation of E-Waste (Management) Rules, 2016}, (HWM Division, CPCB, India 2016)].

The CPCB released a guidelines describing the,

a) Guidelines for Implementing Extended Producer Responsibility,
b) Guidelines for Estimation of E-Waste Generation and Estimation of Target for Collection,
c) Guidelines for Collection and Storage Plan, Collection Centre, Dismantlers & Recyclers,
d) Guidelines for Treatment Storage Disposal Facilities (TSDFs),
e) Guidelines for Collection and Storage of E-waste,
f) Guidelines for Collection Centre, Facilities of Collection Centres,
g) Guidelines for Transportation of E-waste,
h) Guidelines for Environmentally Sound Dismantling of E- Waste, Dismantler,
i) Guidelines for Environmentally Sound Recycling of E- Waste,
j) Guidelines for Refurbishers and
k) Guidelines for Consumers and Bulk Consumers for implementation of the E-Waste (Management) Rules, 2016.

The functions of the recyclers include dismantling along with recovery operation. There shall be no restriction on degree of operations that can be permitted for recyclers provided they have requisite facilities. The following processes should be employed by recyclers:

a) Manual / semi- automatic / automatic dismantling operations
b) Shredding / crushing / fine grinding/wet grinding/ enrichment operations, gravity/

magnetic/density/eddy current separation
c) Pyro metallurgical operations - Smelting furnace
d) Hydro metallurgical operations
e) Electro-metallurgical operations
f) Chemical leaching
g) CRT/LCD/Plasma processing
h) Toner cartridge recycling
i) Melting, casting, moulding operations (for metals and plastics)

A recycling facility may accept e-waste and even those electrical and electronic assemblies¬or components not listed in Schedule- I for recycling, provided that they do not contain any radioactive materials and same shall be declared while taking the authorisation from concerned SPCBs/PCCs.

Trans-boundary movement of E-waste

A study by the Centre for Science and Environment estimates that close to 50,000 metric tonnes of electronic scrap is imported into the country every year. Though the trans-boundary movement of hazardous waste is banned under the Basel Convention, dealers have found ways to get consignments of electronic scrap into the country as they are not properly classified. It is evident from past studies that, most electronic scrap which comes into the country is classified as plastic scrap or mixed waste. This is a serious issue which needs urgent attention since India is a signatory of Basel Convention and is required to enforce strict checking measures to stop entry of illegal E-waste from other countries. However with the implementation of the E-Waste (Management) Rules, 2016, the trans-boundary movement of hazardous waste may be controlled in India.

This indicator can be used to monitor to what extent extended producer responsibility (EPR) is reflected in national recycling policies in encouraging manufacturers, importers and retailers to share the financial and physical responsibilities of collecting, recycling, and disposal of recyclable wastes. Sharing information on good practices and lessons on policy implementation would constitute a useful tool to promote effective policy implementation. The 'E-waste (Management and Handling) Rule 2016' is the first Indian legislation based on the Extended Producer Responsibility principle. As per the rules, producers are responsible for the entire life-cycle of the product from design to waste, including a provision for the reduction of certain hazardous substances in electrical and electronic equipment to below prescribed limits and impose a ban on the import of all used electronic equipment for charity purposes.

VIII. Existence of policies, guidelines, and regulations based on the principle of extended producer responsibility

In India, Extended Producer Responsibility (EPR) has been introduced in the E-waste (Management) Rules 2016. As per the rules, ‘Extended Producer Responsibility’ means responsibility of any producer of electrical or electronic equipment, for channelisation 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 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. Some targets have been specified in the E-waste (Management) Rules 2016, to be fulfilled by authorised EPR bodies mentioned in Table D-22. The rules also have mentioned the EEE codes and average life of different categories of Electrical and electronic equipment, Table D-23.

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.
f) Operation without Extended Producer Responsibility-Authorisation by any producer, as defined in this rule, shall be considered as causing damage to the environment.

Table D-22 Targets specified in E-waste (Management) Rules 2016 for the authorised EPR bodies.

Sl.	Year of implementation	E-waste collection target (Number/ Weight)
1	During First two years of implementation of rules	30% of the quantity of waste generation as indicated in EPR Plan.
2	During Third and Fourth two years of implementation of rules	40% of the quantity of waste generation as indicated in EPR Plan.
3	During Fifth and Sixth years of implementation of rules	50% of the quantity of waste generation as indicated in EPR Plan.
4	Seventh year onward of implementation of rules	70% of the quantity of waste generation as indicated in EPR Plan.

Source: E-waste (Management) Rules 2016

Table D-23 EEE codes and average life of different categories of EEE specified in E-waste (Management) Rules 2016

Sr. No.	Categories of electrical and electronic equipment	EEE Code	Average Life
i.	**Information technology and telecommunication equipment**		
	Centralized data processing:	ITEW1	
	Mainframe		10 Years
	Minicomputer		5 Years
	Personal Computing: Personal Computers (Central Processing Unit with input and output devices)	ITEW2	6 Years
	Personal Computing: Laptop Computers(Central Processing Unit with input and output devices)	ITEW3	5 Years
	Personal Computing: Notebook Computers	ITEW4	5 Years
	Personal Computing: Notepad Computers	ITEW5	5 Years
	Printers including cartridges	ITEW6	10 Years
	Copying equipment	ITEW7	8 Years
	Electrical and electronic typewriters	ITEW8	5 Years
	User terminals and systems	ITEW9	6 Years
	Facsimile	ITEW10	10 Years
	Telex	ITEW11	5 Years
	Telephones	ITEW12	9 Years
	Pay telephones	ITEW13	9 Years
	Cordless telephones	ITEW14	9 Years
	Cellular telephones	ITEW15	
	Feature phones		7 Years
	Smart phones		5 Years
	Answering systems	ITEW16	5 Years
ii.	**Consumer electrical and electronics:**		

Source: E-waste (Management) Rules 2016

IX. GHG Emission from waste sector

The impact of solid waste management on the greenhouse gas (GHG) emissions comes mostly from CH_4 released as biodegradable wastes decay under the anaerobic conditions in landfills. In general, the discussion on GHG emission reduction from solid waste management are avoided landfilling of organic waste, maximized used of organic waste, captured landfill gas for energy use, and avoided burning of plastic waste. Urban India produces about 42 million tonnes of municipal solid waste annually out of which 72.5% is generated and disposed in 423 class-I cities. In order to assess the landfill gas yield of a particular waste stream or combination of waste streams, it is important to understand the composition of the waste stream: in particular the distribution of cellulose and hemi-cellulose (the primary gas generating components of waste) and their degradability.

The total GHG released from waste sector in 2007 was 57.73 million tonnes of CO_2 equivalent, of which, 2.52 million tonnes was emitted as CH_4 emitted and 0.16 million tonnes as $N_2O$with 22% of the emissions from Municipal solid waste disposal (Sharma et. Al., 2011). In India, waste is only systematically collected and disposed at waste disposal sites in cities, resulting in CH_4 emission from anaerobic conditions. In rural areas, waste is scattered and as a result the aerobic conditions prevail with no resulting CH_4 emission. The rate of disposal of MSW varies from city to city therefore the estimation of CH_4 generated from MSW at a national level becomes highly uncertain unless year wise data on MSW generation is incorporated in the estimates. Considering that the amount of recovered methane is zero and oxidation factor is zero, the total methane emitted in 2007 from solid waste disposal site is estimated to be 604.51 Gg.

Source segregation of MSW followed by recycling (for paper, glass, metals, textiles and plastics) and composting /anaerobic digestion (for putrescible wastes) gives the lowest net flux of greenhouse gases, compared with other options for the treatment of mixed MSW. The largest contribution to this effect is the avoidance of emissions from landfills as a result of recycling these materials. Further, segregation of material for recycling at the point at which it is produced (i.e., at households) provides the highest degree of clean, contaminant-free material for recycling.

Emissions estimates and projections from landfill CH_4 (average), wastewater CH_4, wastewater N_2O and incineration $CO_2$are computed in Table D-24 based on reported emissions from national inventories and national communications.

Table D-24 Trends for GHG emissions from waste using (a) 1996 and (b) 2006 IPCC inventory guidelines, extrapolations, and projections from 1990-2050 (Mt CO2eq, rounded)

Source	1990	1995	2000	2005	2010	2015	2020	2030	2050
Landfill CH_4^a	760	770	730	750	760	790	820		
Landfill CH_4^b	340	400	450	520	640	800	1000	1500	2900
Landfill CH_4 (average of a & b)	550	585	590	635	700	795	910		
Wastewater CH_4^a	450	490	520	590	600	630	670		
WastewaterN_2O^a	80	90	90	100	100	100	100		
IncinerationCO_2^b	40	40	50	50	60	60	60	70	80
Total GHG emissions	**1120**	**1205**	**1250**	**1345**	**1460**	**1585**	**1740**		

Sources:[a]1996 inventory guidelines and extrapolations (US EPA 2006).[b]Based on 2006 inventory guidelines and BAU projection (Monni et al. 2006).Waste Management & Research (http://wmr.sagepub.com/)

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Emissions estimates and projections from landfill CH_4 (average), wastewater CH_4, wastewater N_2O and incineration $CO_2$are computed in Table D-24 based on reported emissions from national inventories and national communications.

Table D-25 Trends for GHG emissions from waste using (a) 1996 and (b) 2006 IPCC inventory guidelines, extrapolations, and projections from 1990-2050 (Mt CO2eq, rounded)

Source	1990	1995	2000	2005	2010	2015	2020	2030	2050
Landfill CH_4[a]	760	770	730	750	760	790	820		
Landfill CH_4[b]	340	400	450	520	640	800	1000	1500	2900
Landfill CH_4 (average of a & b)	550	585	590	635	700	795	910		
Wastewater CH_4[a]	450	490	520	590	600	630	670		
WastewaterN_2O[a]	80	90	90	100	100	100	100		
IncinerationCO_2[b]	40	40	50	50	60	60	60	70	80
Total GHG emissions	**1120**	**1205**	**1250**	**1345**	**1460**	**1585**	**1740**		

Sources:[a]1996 inventory guidelines and extrapolations (US EPA 2006).[b]Based on 2006 inventory guidelines and BAU projection (Monni et al. 2006).Waste Management & Research (http://wmr.sagepub.com/)

E: OTHER RELATED ISSUES

I. Categorization of industrial sectors based on the Pollution Index (PI)

The Classification of Industrial Sectors has been revised in February 2016 by introducing a White category over the existing ones, namely, Red, Orange, Green Categories (CPCB, February 29, 2016). The criteria of categorization of industrial sectors have been developed based on the Pollution Index which is a function of the emissions (air pollutants), effluents (water pollutants), hazardous wastes generated and consumption of resources. For this purpose the references are taken from the Water (Prevention and Control of Pollution) Cess (Amendment) Act, 2003, Standards so far prescribed for various pollutants under Environment (Protection) Act, 1986 and Doon Valley Notification, 1989 issued by MoEFCC. The Pollution Index PI of any industrial sector is a number from 0 to 100 and the increasing value of PI denotes the increasing degree of pollution load from the industrial sector. The newly introduced White category of industries pertains to those industrial sectors which are practically non-polluting such as Biscuit trays etc. from rolled PVC sheet (using automatic vacuum forming machines), Cotton and woollen hosiers making (Dry process only without any dying/washing operation), Electric lamp (bulb) and CFL manufacturing by assembling only, Scientific and mathematical instrument manufacturing, Solar power generation through photovoltaic cell, wind power and mini hydel power (less than 25 MW). In the 'Re-categorization' exercise due importance has been given to relative pollution potential of the industrial sectors based on scientific criteria. Further, wherever possible, splitting of the industrial sectors is also considered based on the use of raw materials, manufacturing process adopted and in turn pollutants expected to be generated. Following criteria on 'Range of Pollution Index 'for the purpose of categorization of industrial sectors is finalized.

- Industrial Sectors having Pollution Index score of 60 and above – Red category
- Industrial Sectors having Pollution Index score of 41 to 59 – Orange category
- Industrial Sectors having Pollution Index score of 21 to 40 – Green category
- Industrial Sectors having Pollution Index score incl. & up to 20 - White category

Newly introduced White category contains 36 industrial sectors which are practically non-polluting. The Red category of industrial sectors would be 60. The Orange category of industrial sectors would be 83. The Green category of industrial sectors would be 63. There shall be no necessity of obtaining the Consent to Operate" for White category of industries. An intimation to concerned SPCB / PCC shall be sufficient. No Red category of industries shall normally be permitted in the ecologically fragile area / protected area.

II. Green Manufacturing in Industries for 3R Implementation

Government of India has envisioned 'Make in India' and 'Zero Defect & Zero Effect (ZED)' Manufacturing for which there is need of a policy which will create an ecosystem for competitive, quality and clean manufacturing, promote development of world class products, expand markets for MSME. The Ministry of Micro, Small & Medium Enterprises has launched the "Financial Support to MSMEs in ZED Certification Scheme" for the benefit of MSMEs during the 12th Five-year Plan in November 2016. (Source: Guidelines For the Implementation of Financial Support to MSMEs in ZED Certification Scheme, Development Commissioner (Micro Small and Medium Enterprises) Ministry of Micro, Small and Medium Enterprises, Government of India, 2016).

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. To supplement the impact of these laws, the Government has launched eight major initiatives as national 'missions' to promote Green, the most prominent of them being the National Solar Mission to promote Green energy Refer to the Section C: country situation of this report.

According to a report by the UN Environment Program (UNEP) – 'Global Trends in Sustainable Energy Investment 2010' released in July 2010 – India was ranked seventh in the world in terms of investment in sustainable energy. Under the National Solar Mission, the Government plans to generate 20,000 MW of solar power by 2022 in three phases, with 2000 MW capacity equivalent off–grid solar applications. India is the fifth largest wind energy producer in the world with an installed capacity of around 11,500MW and has three times this wind potential it can still tap. Similar aggressive targets have been set for hydro and nuclear power generation. The 11th Five Year Plan has set a target of increasing energy efficiency by 20 percent and the Government is also offering tax holidays, soft loans, subsidies and other incentives for renewable energy projects. The Government has set up the Indian Renewable Energy Development Agency (IREDA) as a public sector unit for market development and financing. The Bureau of Energy Efficiency (BEE) was set up to support awareness and demand creation for energy efficient products, goods and services. BEE has set up the Energy Efficiency Financing Platform (EEFP) for supporting the cost effective financing of energy efficiency project implementation and its expansion. In the Union Budget 2010–11, the Government announced setting up of National Clean Energy Fund (NCEF) for funding research and innovative projects in clean technologies. The Central Electricity Regulatory Commission (CERC) has announced Renewable Energy Certificate (REC) norms in a bid to promote power generation from clean sources in the country.

Ensuring competitiveness of India's MSME is critical as it will contribute to the overall growth of the manufacturing sector and the country's economy. International companies competing in global markets focus on their competitive strengths of costs acceptable to the market, technology, innovation, service delivery, lean manufacturing, and defect free products for Zero Defect and Zero Effect (ZED). At present our GDP (14%) is only a little below the average for lower middle-income countries (15.80%) and significantly below the average for upper middle-income economies (23.05%). The main aim of the scheme is based on 3R to achieve resource efficient operations leading to better quality of products and services with cost effectiveness.

ZED has presented a model where the concept of quality has a holistic change from a tool for compliance to a source of competitiveness. Operationally, it is meant to evolve from a total dependency on inspection of the final product to correct defects, to a proactive process of improving processes like quality planning, product and process designing, optimum processes, efficient resource management, effective outsources activities and breakthrough outcomes. Along with a focus on quality of products and services, there is an equal emphasis on the elimination of impact on the environment through adequate planning at product and process design, pre-production (start-up activities), production and maintenance activities, post production (disposal after use) and outcome of environment performance by reducing significant energy and environment aspects and business risk. Overall, the net result is sustainable development.

The ZED scheme is an integrated and holistic certification system that will account for quality, productivity, energy efficiency, pollution mitigation, financial status, human resource and technological depth including design and IPR in both products and processes. The parameters of the scheme will cover all aspects of the existing schemes of Ministry of MSME: Quality Management System (QMS) / Quality Technology Tools (QTT), Lean Manufacturing Competitiveness Programme (LMCS), Design Clinic and Technology and Quality Up-gradation (TEQUP), and Building Awareness on Intellectual Property Rights (IPR).

III. Green Building Code and Smart City for 3R Implementation in building construction

India is witnessing tremendous growth in infrastructure and construction development. The construction industry in India is one of the largest economic activities and is growing at an average rate of 9.5% as compared to the global average of 5%. As the sector is growing rapidly, preserving the environment poses a host of challenges. To enable the construction industry environmentally sensitive, the Indian Green Building Council (IGBC) was established. IGBC, is a consensus driven not-for-profit Council, represents the building industry, consisting of more than 1,923 committed members. The Council encourages, builders, developers, owners, architects and consultants to design & construct green buildings, thereby enhancing the economic and environmental performance of buildings. The Green Building Movement in India has been spearheaded by IGBC since 2001, by creating awareness amongst the stakeholders. Thus far, the Council has been instrumental in enabling 2.23 Billion sq.ft of green buildings in the country. The Council's activities have enabled a market transformation with regard to green building materials and technologies. IGBC continuously works to provide tools that facilitate the adoption of green building practices in India.

The building sector in India is growing at a rapid pace and contributing immensely to the growth of the economy. This augurs well for the country and now there is an imminent need to introduce green concepts and techniques in this sector, which can aid growth in a sustainable manner. The green concepts and techniques in the building sector can help address national issues like water efficiency, energy efficiency, reduction in fossil fuel use for commuting, handling of consumer waste and conserving natural resources and use of recycled C&D wastes. Most importantly, these concepts can enhance occupant's health, productivity and well-being. Against this background, the Indian Green Building Council (IGBC) has launched 'IGBC Green New Buildings rating system® to address the national priorities. This rating programme is a tool which enables the designer to apply green concepts and reduce environmental impacts that are measurable. The rating programme covers methodologies to cover diverse climatic zones and changing lifestyles.

Green building materials are made from either recycled or renewable sources, which reduces deforesting or waste. Additionally, these items are often manufactured or harvested locally and can be broken down and reused, completing the Life-Cycle Assessment. To meet these criteria, materials must be certified by an independent third party. Green materials reduce the amount of energy consumption required to operate a home or office. They incorporate alternative forms of energy, thermal efficiency, load reduction and energy waste reduction to minimize the energy footprint of a home or office. Furthermore, these products are manufactured using energy efficient technology and methods. *(Source: IGBC Green New Building Rating System, Indian Green Buildings Council, Sept 2014).*

Smart City Mission launched in June, 2015, the flagship scheme of the present government. A smart city is an urban development vision to integrate information and communication technology (ICT) and Internet of things (IoT) technology in a secure fashion to manage a city's assets to improve the efficiency of services. Smart Cities Mission is an urban renewal and retrofitting program by the Government of India with a mission to develop 100 cities (the target has been revised to 109 cities) all over the country making them citizen friendly and sustainable with an investment plan of nearly 980.billion INR (US$15 billion). Smart Cities will promoting the implementation of 3Rs through, namely, making areas less vulnerable to disasters, using fewer resources, more efficient mixed land-use based developments–planning for 'unplanned areas' containing a range of compatible activities, reduce congestion, air pollution and resource depletion and boost local economy, preserving and developing open spaces - parks, playgrounds, and recreational spaces in order to enhance the quality of life of citizens, reduce the urban heat effects in areas and generally promote eco-balance; Promoting a variety of transport options - Transit Oriented Development (TOD), public transport and last mile para-transport connectivity; establishing necessary administrative services are offered within walking or cycling distance; Forming e-groups to listen to people and obtain feedback and use online monitoring of programs and activities with the aid of cyber tour of worksites; Giving an identity to the city - based on its main economic activity, such as local cuisine, health, education, arts and craft, culture, sports goods, furniture, hosiery, textile, dairy, etc.

IV. End-of-Life Vehicles (ELVs)

The automobile industry has become an integral part of human history. In India, production of automobiles took off in the early 1990s, this has become one of the country's fastest growing industry sector. In 2010 the number of vehicles were more than 110 million that included passenger vehicles, commercial vehicles, three wheelers (3W) and two wheelers (2W) (Chaturvedi et al. 2012), a key observation was that the vehicle ownership has increased considerably. As per Society of Indian Automobile Manufacturers (SIAM), an additional 10,37,88,457 vehicles were produced in the period 2010 - 2015. In 2014-15 alone, the production was 2,33,66,246 vehicles of which 32,20,172 were passenger vehicles, 6,97,083 were commercial vehicles, 9,49,021 were three wheelers and 1,84,99,970 were two wheelers. Two wheelers accounted for 80% of vehicles sold by number and about 40% by weight.

The guidelines for environmentally sound management of End- Of - Life Vehicles (ELVs) was published by the Central Pollution Control Board (CPCB), Govt. of India in November 2017 which provides guidance for proper handling of ELVs at every stage, proposes "shared responsibility" scheme and offers a platform for development of enabling policy framework. India is close to formulating its own legislation on management and recycling of End-of-life Vehicles (ELVs). In 2015 the Automotive Industry standard (AIS Committee 2015) Committee published a detailed set of mandatory Automotive Industry Standards (AIS 129). The AIS 129 suggest that vehicle manufacturers support ELV recycling through improved product design and information dissemination. A draft of Automotive Industry standard AIS 129 has also been developed by Automotive Research Association of India (ARAI), a co-operative industrial research association by the automotive industry with the ministry of Industries, Government of India, which is focused on ELVs. The ELVs number is projected to explode to over 0.02 billion by 2025.The number of registered vehicles in India was around 160 million as in 2014 and growing rapidly. The number of vehicles registered in India between the year 1991 and 2000 was 30.55 million. Figure E-1 gives the data on domestic vehicle market share (%) 2013/2014 (Source: SIAM 2015).

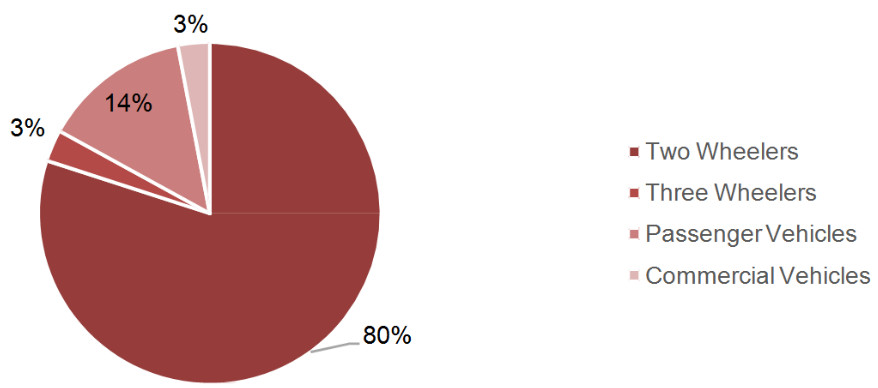


Figure E-1 Domestic vehicle market share (%) 2013/2014 (SIAM 2015)

A recent study in 2015 by Central Pollution Control Board (CPCB) and Indo German Environment

Partnership (GIZ-IGEP) in major automobile hubs like Chennai, Pune, Kolkata, Indore and Jamshedpur has mapped the key problem areas and the trade chain covering informal sector workers engaged in collection, dismantling, trading and recycling of ELVs.

Due to the increase in the vehicular population in India it has been estimated that more than 8.7 million vehicles will reach ELV status by 2015 out of which 83% are likely to be two wheelers. For 2025 it is estimated that the number of vehicles to become ELV will be 2,18,95,439. Two-wheelers will probably account for about 80% of the total ELVs. The survey compiled the obsolence rate of each category of vehicles, based on the vehicles sold 15 years back, it is estimated that 8.7 million vehicles would have reached ELV status or obsolete in 2015. Table E-1 gives the Total ELV count in 2015 and the projection in the year 2025.

Table E-1 Total ELV count in 2015 & 2025

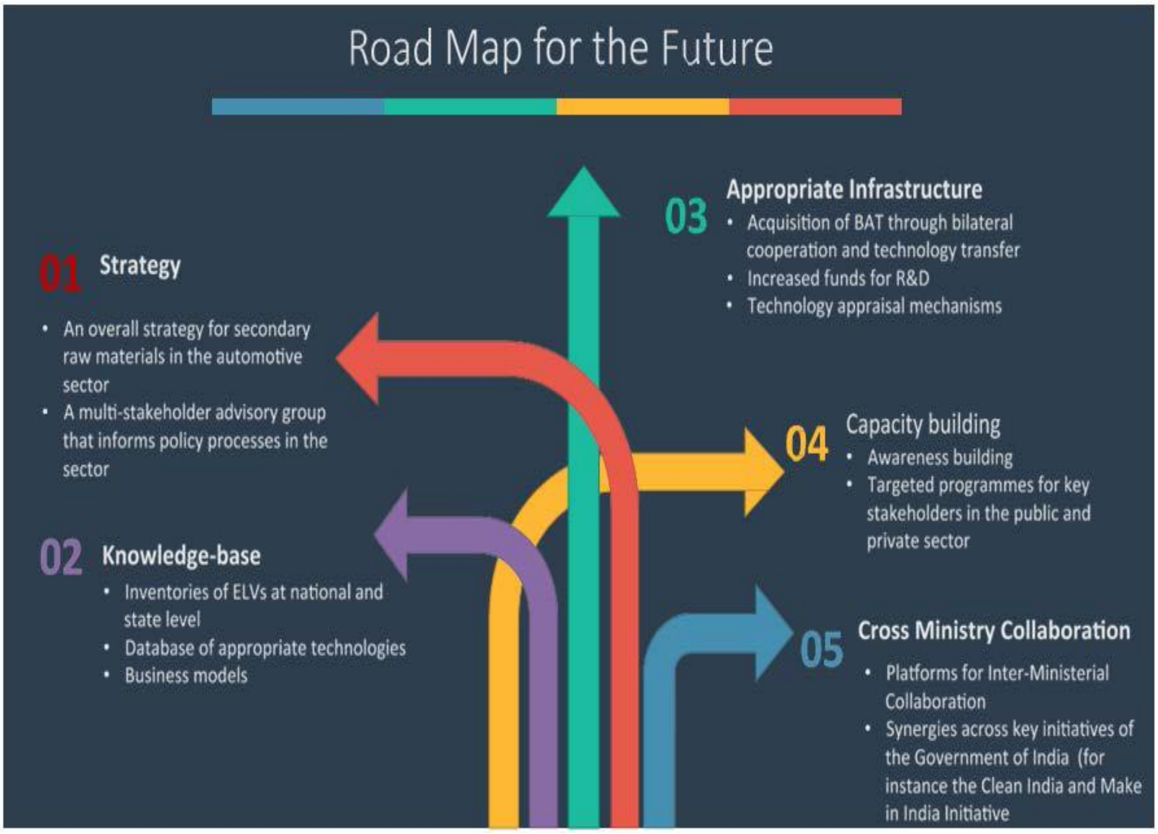
Type of Vehicles	Total ELV count in 2015
Two-wheelers	7,289,422
Three- wheelers	262,439
Private Cars / SUVs	721,558
Commercial passenger Vehicle	46,522
Commercial goods Vehicles	4,112,230
Total ELVs approximately	8,731,185
Types of vehicles	**Total ELV count in 2025**
A: Two Wheelers	17,723,951
B: Three Wheelers	757,932
C: Private Cars/SUVs	2,809,966
D: Commercial passenger Vehicles	1,188,833
E: Total vehicle likely to be ELV in 2025	21,895,439

Source: Guidelines for environmentally sound management of End- Of - Life Vehicles (ELVs), 2016, CPCB, India

The policy goals for the proposed ELV management system are:

a) Decrease open dumping of ELVs.
b) Encourage re-use, recycling and other forms of recovery of ELVs.
c) Reduce the uncontrolled disposal of ELVs by the semi-formal sector.
d) Control the usage of Hazardous Substances in new vehicles.
e) Contribute to the efficient use of resources and the retrieval of valuable secondary raw materials.
f) Improve the environmental performance of all operators involved in the life cycle of ELVs (e.g., manufacturers, importers, distributors, consumers, collectors, dismantlers, recyclers, and exporters).
g) Set up a “Shared Responsibility” scheme.
h) Engage consumers and businesses - Business-to-business (B2B) and Business-to- consumer (B2C).

In the guidelines for environmentally sound management of end-of-life vehicles (ELVs), published by the CPCB, GoI in 2016, the elements of a ELV Roadmap for strategies, knowledge base requirements, required infrastructure, capacity building and cross ministry collaboration for India that will definitely help in implementing environmentally sound management of ELVs that is shown in Figure E-2.



Source: Guidelines for environmentally sound management of End- Of - Life Vehicles (ELVs), 2016, CPCB, India

Figure E-2 Elements of an ELV Roadmap for India

Car Registrations in India increased to 262,735 Cars in March from 240143 Cars in February of 2017. Car Registrations in India averaged 107,054.11 Cars from 1991 until 2017, reaching an all time high of 304,900 Cars in March of 2012 and a record low of 6508 Cars in April of 1992. A sizeable portion obviously is obsolete.

At present there are 149 registered dismantler/recycler having dismantling and recycling capacity of 462,896 tonnes per annum. One hundred and thirty two (154) collection centres have been granted authorisation in eighteen (18) States/UTs in India. Other SPCBs/PCCs have reported nil authorized collection centres in their States/UTs. Hundreds end-of-life vehicles (ELVs) are stripped in Delhi, Kolkata, Pune, Jamshedpur, Indore, Chennai and several places by many informal, unregulated clusters across the country — which have turned into hubs for scrap metal and all sorts of recovered and refurbished automobile parts. This, unfortunately, is how India deals with its old vehicles when Europe, United States and Japan have robust process for de-registering ELVs with dismantling units working in tandem with industry and government. Sweden had put in place an elaborate car scrappage law way back in 1975. In India there is no ELV policy or law and no scrappage infrastructure - vehicle inspection and certification (I&C) networks for fitness testing and dismantling units - in the organised sector. A typical passenger car consists of about 70% steel and iron by weight. and 7-8% aluminium, the rest 20-25% is plastic, rubber, glass etc., which are also recyclable. (Sakai et al., 2013). In India, vehicles have much potential for re-use up to 70% of a vehicle are dismantled and directly re-used or sold to other manufacturers (CPCB, 2015). Table E-2 gives the inventory of raw material savings to produce fresh steel through recycling process and Table E-3 gives the estimated scrap value out of ELVs in India.

Table E-2 Raw Material Savings to produce fresh steel through recycling process

Raw Material	Quantity of raw material saved* (mt)	Estimated price of raw material (Rs. Per ton)	Estimated savings (Rs. billion)
Iron ore	21.02	3,000	63.06
Coal	11.68	8,000	9,.42
Limestone	5.84	2,500	14.60
		Total:	**171.08**

* Through recycling of 12.85 million tonnes of auto scrap

Source: GIZ-CPCB& SIAM, 2016

Table E-3 Estimated Scrap Value out of ELVs in India

Category	Estimated Scrap Value (Rs.)	Benefit to vehicle user (Rs.) (85% of scrap value)	Benefit to dealer (Rs.) (15% of scrap value)
Two Wheeler	1,500 – 3,000	1,275 – 2,250	225 – 400
Passenger Vehicle	13,000 – 20,000	11,050 – 17,000	1,950 – 3,000
Commercial Vehicle	1,00,000 – 1,50,000	85,000 – 1,27,500	15,000 – 22,500
Three Wheelers	5,000 – 10,000	4,250 – 8,500	750 – 1,500

Source: GIZ-CPCB &SIAM, 2016

V. Construction and Demolition (C&D) Waste Management

C&D waste from individual households finds its way into nearby municipal bins and waste storage depots making the municipal waste heavy, and degrading its quality for treatments such as composting or energy recovery. In India its common practice for large Construction and Demolition (C&D) projects to pile waste on the road side, resulting in traffic congestion. The Indian construction industry is highly labour intensive and has accounted for approximately 50% of the country's capital outlay in successive Five Year Plans, and projected investment continues to show a growing trend. Out of 62million tonnes of solid waste generated in India, C&D waste makes up 25% annually.

MoEF&CC has notified separate Construction and Demolition Waste Management Rules, 2016 on March 29, 2016 for proper collection, transportation & disposal/recycling of C&Dwaste.

The Government has notified Construction & Demolition Waste Management Rules, 2016 for the first time in India as an initiative to effectively tackle the issues of pollution and waste management. The construction & demolition waste generated is about 530 million tonnes annually at present. Segregating construction and demolition waste and depositing it to the collection centres for processing will now be the responsibility of every waste generator.

The Environment Minister highlighted that the local bodies will have to utilize 10-20% material from construction and demolition waste in municipal and government contracts. The cities with a population of more than one million will commission processing and disposal facility within 18 months from the date of final notification of these rules, while cities with a population of 0.5 to 1 million and those with a population of less than 0.5 million will have to provide these facilities within two years and three years respectively. "Permission for construction will be given only when the complete construction and demolition waste management plan is presented". The large generators of C&D waste will have to pay relevant charges for collection, transportation, processing and disposal, as notified by the concerned authorities (Source : MoEF&CC, notification dated 29th March 2016, http://pib.nic.in/newsite/PrintRelease.aspx?relid=138389 as viewed on 23.04.2017).

Every waste generator shall segregate construction and demolition waste and deposit at collection centre or handover it to the authorised processing facilities and shall ensure that there is no littering or deposition so as to prevent obstruction to the traffic or the public or drains. Large generators (who generate more than 20 tonnes or more in one day or300tonnes per project in a month) shall submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodelling work. Large generators shall have environment management plan to address the likely environmental issues from construction, demolition, storage, transportation process and disposal / reuse of C&D Waste. Large generators shall segregate the waste into four streams such as concrete, soil, steel, wood and plastics, bricks and mortar. Large generators shall pay relevant charges for collection, transportation, processing and disposal as notified by the concerned authorities; The service providers shall prepare a comprehensive waste management plan for waste generated within their jurisdiction, within six months from the date of notification of these rules and shall remove all construction and demolition waste in consultation with the concerned local authority on their own or through any agency. The processing/recycling facility exceeding five tonnes per day capacity, shall maintain a buffer zone of no development around the facility.

Total C&D waste generated in year 2000 was approximately 13-15 million tonnes. Comprehensive study for C&D waste estimation was done by TIFAC [5]. This study presented following data related to C&D waste in India for the year 2000, the C&D waste was estimated as 14.69 million tonnes. The Waste generation during construction and renovation/ repair work was 40 to 60 and 40 to 50 kg/m^2 respectively. The highest contribution to waste generation was from demolition of buildings, which yielded on average 425 kg/m^2 of waste.

In India though the construction and demolition waste is one of the major issues for effective waste management, only two CD Waste Recycling plants are presently working in Delhi with a capacity of 2000 tpd and in Ahmedabad with a capacity of 500 tpd. There are matured plans of installing CD

Waste recycling plants in New Town, Kolkata, Bangalore, Madhya Pradesh, and in several municipalities as a follow up action of the Construction and Demolition Waste Management Rules, 2016.

VI. Bio-medical Waste Management

The Bio-medical Waste (Management & Handling) Rules, stipulates that "Bio-medical Waste shall be treated and disposed of in accordance with the prescribed standards using requisite bio-medical waste treatment facilities like incinerator, autoclave, microwave system for the treatment of waste or ensure requisite treatment of waste at a common waste treatment facility or any other waste treatment facility. The rules prohibit the mixing of bio-medical waste with other wastes. It establishes that biomedical waste shall be segregated into containers or bags at the point of generation prior to its storage, transportation, treatment and disposal. As per the Annual Report 2013 submitted by the State Pollution Control Boards , there are22,245 Health Care Facilities (HCFs) having on-site treatment facilities apart from 198 Common Bio-Medical Waste Treatment Facility (CBWTFs) providing treatment services to the 1,31,837 HCFs. Further, CPCB issued guidelines on "Common Bio-medical Waste Treatment Facilities, Design & Construction of Bio-medical Waste Incinerator, disposal of bio-medical waste generated during the Universal Immunization Programme and for management and handling of mercury waste generated from the Health Care Facilities".

The total Bio-medical waste generated in the country is 484 tonnes per Day out of which 447 TPD is treated and disposed of by the facilities inside the health care unit or common facilities. The Bio-medical Waste (Management & Handling) Rules, 1998 and amendments thereof (hereafter referred as BMW Rules) were notified under the Environment (Protection) Act, 1986 by the Ministry of Environment, Forests & Climate Change in the year 1998 and further amendments issued in the year 2000 and 2003. As per BMW Rules, 1998, State Pollution Control Boards (SPCBs) / Pollution Control Committees (PCCs) in the respective States/UTshave been notified as the 'Prescribed Authority' for overall enforcement of the said Rules. The Rules have been revamped in 2016 as Bio-Medical Waste Management Rules, 2016.As per the annual report information received from the State Pollution Control Boards (SPCBs)/ Pollution Control Committees (PCCs) and Director General of Armed Forces Medical Services (DGAFMS) for the year 2013, the detailed bio-medical waste management scenario in the Country is given below. (Source: CPCB Bulletin Vol.- I, July 2016, Govt. of India).

- Quantity of bio-medical waste generated in Tonnes/day : 484
- Quantity of bio-medical waste treated in Tonnes /day : 447
- No. of healthcare facilities: 1,68,869
- No. of beds : 17,13,816
- No. of Common Bio-medical Waste Treatment Facilities (CBWTFs) : 226
- [198 (in operation) + 28 (CBWTFs under installation)]
- No. of healthcare facilities (HCFs) using CBWTFs: 1,31,837
- No. of HCFs having treatment & disposal facilities: 22,245
- No. of healthcare facilities applied for authorization: 1,06,805

- No. of healthcare facilities granted authorization: 1,05,270

Total no. of on-site/captive treatment equipment installed (excluding CBWTFs) by the HCFs:

· No. of incinerators With Air Pollution Control Device: 331 · No. of incinerators Without Air Pollution Control Device: 217	· No. of Shredders: 5,179 · No. of Hydroclave: 15 · No. of autoclaves: 3,112 · No. of microwaves: 250

Treatment equipment installed by Common Bio-medical Waste Treatment Facilities (CBWTFs)

· No. of incinerators : 198 · No. of autoclaves: 189 · No. of microwaves: 06 · No. of Hydroclave: 03 · No. of Shredders: 202	· Quantity of bio-medical waste generated in Tonnes/day: 484 · Quantity of bio-medical waste treated in Tonnes /day: 447 · No. of HCFs violated BMW Rules: 7,894 · No. of Show-cause notices/Directions issued to defaulter HCFs: 4,391

F: EXPERTS ASSEEMENT ON WASTE MANAGEMENT AND 3R POLICY

I. Solid waste management practices and challenges in India

In India, MSWM is governed by MSWR. However, majority of ULBs do not have appropriate action plans for execution and enactment of the MSWR (CPCB Report, 2013). Unfortunately, no city in India can claim 100% segregation of waste at dwelling unit and on an average only 70% waste collection is observed, while the remaining 30% is again mixed up and lost in the urban environment. Out of total waste collected, only 12.45% waste is scientifically processed and rest is disposed in open dumps (CPCB Report, 2013). The Waste generation and Future Predictions until 2041 is shown in Table D-5. (Page 32). Environment friendliness, cost effectiveness, and acceptability to the local community are major attributes to achieve efficient solid waste management system.

There is a common view of scavengers are nuisances and even threats to public health. They are seen as interfering with waste collection operations. Local authorities may make good use of them effectively allowing their activities to be included in the overall MSWM system by contracting to small-scale waste collection enterprises of waste pickers and itinerant collectors. Such facilitation to develop the rag pickers as micro entrepreneurs to offer waste collection services will be beneficial to the municipality in the form of efficient waste collection at less cost and absence of rag picker interference at waste processing/disposal facilities. This will also improve the working conditions and earning capacity of the rag pickers. Recycling industry needs technological upgradation to improve the quality of the product, reduce cost and minimize potential health hazards.

Waste generated at households is generally accumulated in small containers (often plastic buckets/bags) until it is disposed into community bins built by the Civic bodies. Containers used for household storage of solid wastes are of many shapes and sizes, fabricated from a variety of materials depending on the economic status of the waste generator. The wide variety of types and shapes commonly encountered within a community creates difficulty in establishing and operating an efficient solid waste collection system. MSW is collected through methods like community bin collection and house-to-house collection on regular pre-informed timings and scheduling by using musical bell of the vehicle. Commercial wastes are also collected along with the household wastes except in a rare number of commercial complexes where they pay a negotiated fee to the municipality for collecting waste from their premises. Wastes from slaughterhouses, meat and fish markets, fruits and vegetable markets, which are biodegradable in nature, are also collected along with other wastes.

Source segregation of biodegradable and recyclable wastes at household level is seldom practiced and the door to door collection practiced in some cities and the community collections bins used in most cities are not well designed to have separate compartments for recyclable and organic wastes. Though, the MSW Rules (requires that the bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be painted white and those for storage of other wastes shall be painted black, it is seldom practiced. Urban Local Bodies (ULBs) spend about Rs.500 to Rs.1500 per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on street sweeping of waste collection, 20 to 30% on transportation and less than 5% on final disposal of waste, which shows that hardly any attention is given to scientific and safe disposal of waste. Landfill sites have not yet been identified by many municipalities and in several municipalities, the landfill sites have been exhausted and the respective local bodies do not have resources to acquire new land. Due to lack of disposal sites, even the collection efficiency gets affected.

The major problems and challenges related to MSW collection systems are summarized in Table F-1. Lack of an established system for segregation of recyclable, organic and inorganic wastes at household level, collection, transportation, treatment, disposal and complete integration of the system are the major challenge in the proper management of waste.

Table F-1 Summary of Waste Management Challenges

Sl. No.	Element of Waste Management	Issues
1	Waste Segregation	· Poor public support · ULBs are not having segregated waste collection (two bin) system · Lack of waste processing facilities
2	Primary collection	· Poor public support for storage of waste at source · Lack of Door–to–Door (D2D) collection system · Poor waste collection in slums · Low user fee collection (20 to 40%) · Poor Enforcement of Law against defaulters and poor support of elected representatives for user fee collection
3	Secondary Collection & Transportation	· Frequent shifting of storage containers · Manual handling of waste without safety measures. · Littering of storage points and during transport · Poor monitoring system by ULBs
4	Treatment and Disposal	· Public litigation and difficulty in facility sitting · Lack of Technical Capacity with ULBs · Political interference · Lack of monitoring

Sl. No.	Element of Waste Management	Issues
5	Administration & Planning	· Lack of vision and planning for creating awareness · Lack of seriousness of issue among the local bodies, elected representatives and community · Lack of integrated action plan · Poor consultation with community /public · Institutional weakness and human resources · Poor commitment of Waste Managers · Mix of Bio- Medical & industrial wastes with municipal solid waste. · Poor efforts to channelize funding opportunities

Source: Prepared by author

Often cited reasons for poor operation and maintenance of waste management systems are inadequate finance, overburdening of the local bodies responsible for proper disposal of urban waste, inadequately trained personnel, poor performance monitoring and inadequate emphasis on preventive maintenance. It includes the facts that (i) most households do not deposit their wastes into the community bins which result in wastes being thrown on roadside (ii) many community bins are at most of the times overflowing causing unhygienic conditions and (iii) rag pickers poaching on the community bins for retrieving recyclable wastes are spilling wastes around the bins. Such wastes left mostly on the street until the next day's collection, means that the streets are mostly littered, even if there is regular collection services. Poor civic discipline and inadequate community storage arrangements make the householders to often throw their wastes onto the roadsides for clearance by street sweeping crews, which adds to the inert content of wastes.

II. Current Status and Challenges on 3Rs

It is expected that the new waste management rules will enforce all the municipalities and municipal corporation to adopt applicable waste recycling and treatment options leading the least amount of wastes, mainly inert, to the landfill. Various components of MSW have an economic value and can be recovered, reused or recycled cost effectively. Currently, the informal sector picks up part of the resources from the streets and bins to earn their living. However, a sizeable portion of organic waste as well as recyclable material goes to landfills untreated. Over 81% of MSW annually is disposed at open dump sites without any treatment. With planned efforts to Reduce, Reuse, Recover, Recycle and Remanufacture (5Rs) and appropriate choice of technology, the country can profitably utilize about 65% of the waste in producing energy and/or compost and another 10 to 15% to promote recycling industry and bring down the quantity of wastes going to landfills/ dumps below 20%.

As a strategy, it would be prudent to make efforts to motivate the waste generators to reduce generation in the first place and reuse the waste to the extent possible, guide and enable industry and commerce to enhance recovery of materials and intermediates during manufacturing, promote segregation of recyclables at source and re-use the material in re-manufacturing of products and intermediates, transitioning towards achieving the goal of optimum utilization of recyclable material.

The percentage of wet biodegradable waste is high in Indian waste and is a source of contamination of soil, water and air, if disposed indiscriminately.

In annexure 1 of this document several options and information are given for effective MSW management as follows (So*urces: Planning Commission Report 2014, Govt. of India)*:

- Options available for Municipal Solid Waste treatment and utilisation
- Logic Diagram for Selection of Integrated Municipal Solid Waste Management Scheme for a given Local Self Government
- Integrated MSW Management System(MSWM) for the Population of more than 2 million
- Integrated MSW Management System for the Population Ranging from 1 to 2 million
- Integrated MSWM System for the 1 - 10 lakh Population as well as for Hill Towns
- Integrated MSWM System for the Population Less than 1 lakh
- General Framework for Integrated Municipal Solid Waste Management Scheme
- Population based Technological options to Manage MSW in Towns and Cities
- Population based Technological options to Manage MSW in Towns and Cities
- Tentative Capital cost estimates for processing various fractions of MSW

It may be seen that most of the 3R related legal initiatives in India pertain to wastes and emissions from industrial activities. The criteria on 'Range of Pollution Index' for the purpose of categorization of industrial sectors as introduced in February 2016 will definitely help in curbing the pollution from industries. The charter on Corporate Responsibility for Environmental Protection is a mutually agreed document between the Government and industrial houses, incorporating voluntary initiatives. The measures to be taken by the industry include modernisation and technological up gradation of production processes, changing over to green technologies, introduction of lean and green manufacturing systems, waste minimization, reduced use of resources, introducing robust reverse logistics, and re-cycling waste. It also include activities such as installation of pollution control and monitoring equipment, improving housekeeping practices and furnishing bank guarantees by the defaulting industries till compliance is ensured. Low Carbon and Climate Change Circle (LC4), a team activity concept of small group of 3 to 10 within the unit (S.K. Ghosh, 2015)and Waste Minimization Circle (WMC), a concept of small group (5 to 7 units) of entrepreneurs in the small scale sector, whose units manufacture similar products and employ the same processes voluntarily meeting periodically and regularly in the premises of each member unit, one after another, to analyze the current operations of the host unit, so as to assist such industries in adoption of cleaner production processes.

III. Indian Status of Related Hanoi 3R Goals

The 3Rrelated goals set by 3R Forum, associated indicators and the Indian status is summarised in Table F-2 and explained in this section.

Table F-2 3R Goals, Indicators and Indian Status

3R Goals	3R Indicators	Indian Status
Significant reduction in the quantity of municipal solid waste generated.	Total MSW Generated and Disposed and MSW Generation Per Capita	per capita generation of MSW in India, vary from 200 g to 800 g per day
Significant increase in recycling rate of recyclables	Overall Recycling Rate and Target (%) and	Both formal and Informal recycling in practice.

3R Goals	3R Indicators	Indian Status
	Recycling Rate of Individual Components of MSW	No specific data on recycling rates. No specific Targets for recycling of MSW Components. SWM Rules 2016 specified that the MSW should be segregated, recycled, composted, energy recovered and the least quantity should be disposed in landfill sites.
Develop proper classification and inventory of hazardous waste	Amount of Hazardous Waste Generated and Disposed in Environmentally Sound Manner	62,32,507 tonnes of hazardous wastes every year. Landfillable– 27,28,326 MTA(tonnes/annum); Incinerable HW - 4,15,794 MTA; And Recyclable HW - 30,88,387 MTA.
Improve resource efficiency and resource productivity by greening jobs nation-wide in all economic and development sectors.	Indicators based on macro-level material flows	No specific data
Promote full scale use of agricultural biomass waste and livestock waste through reuse and/or recycle measures	Amount of agricultural biomass to be used	500 million tonnes of crop residues are generated annually. Several Government schemes encourage effective utilisation of biomass and gets subsidy on power price to grid and loan from financial institutes with support from government (MNRE & MUD)
Strengthen regional, national, and local efforts to address the issue of waste, in particular plastics in the marine and coastal environment.	Marine &coastal plastic waste quantity (Primary)	No specific data
Ensure environmentally sound management of e-waste	Amount of E-waste Generation, Disposal and Recycling. Existence of policies and guidelines for E-waste management	0.8 million tonnes of e-waste generated per year in the country. 1,21,381 MTA recycled by registered dismantlers and recyclers as against their capacity of 4,55,059 MTA.
Progressive implementation of Extended Producer Responsibility (EPR)	Existence of policies, guidelines, and regulations based on the principle EPR	EPR practiced for E-wastes and Lead acid batteries
Maximize co-benefits from waste management technologies for local air, water, oceans and soil pollution and global climate change	GHG Emission from waste sector	Total GHG released from waste sector in 2007 was 57.73 million tonnes of CO_2equivalent, of which, 22% from Municipal solid waste disposal.

Source: Prepared by author

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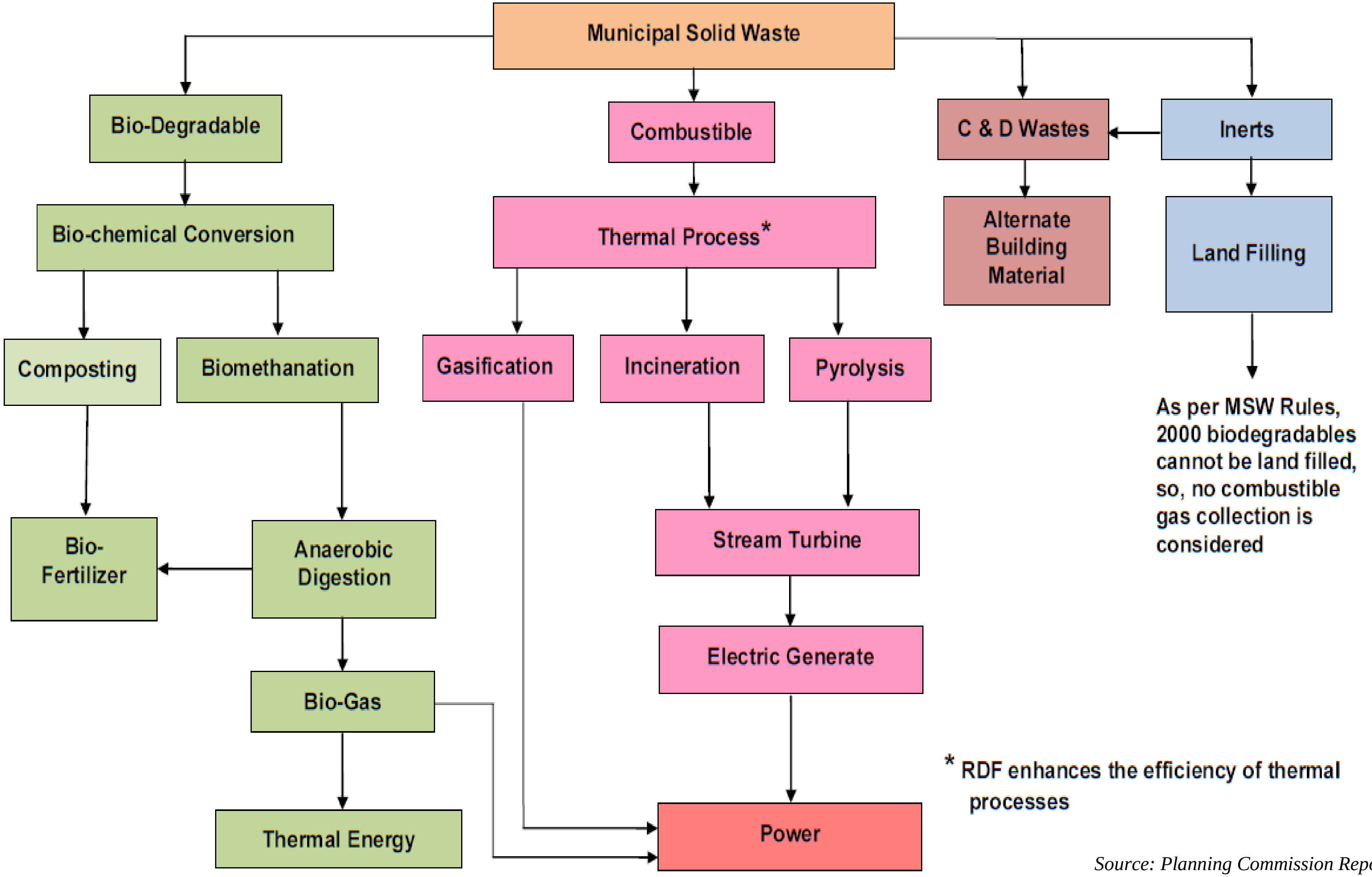
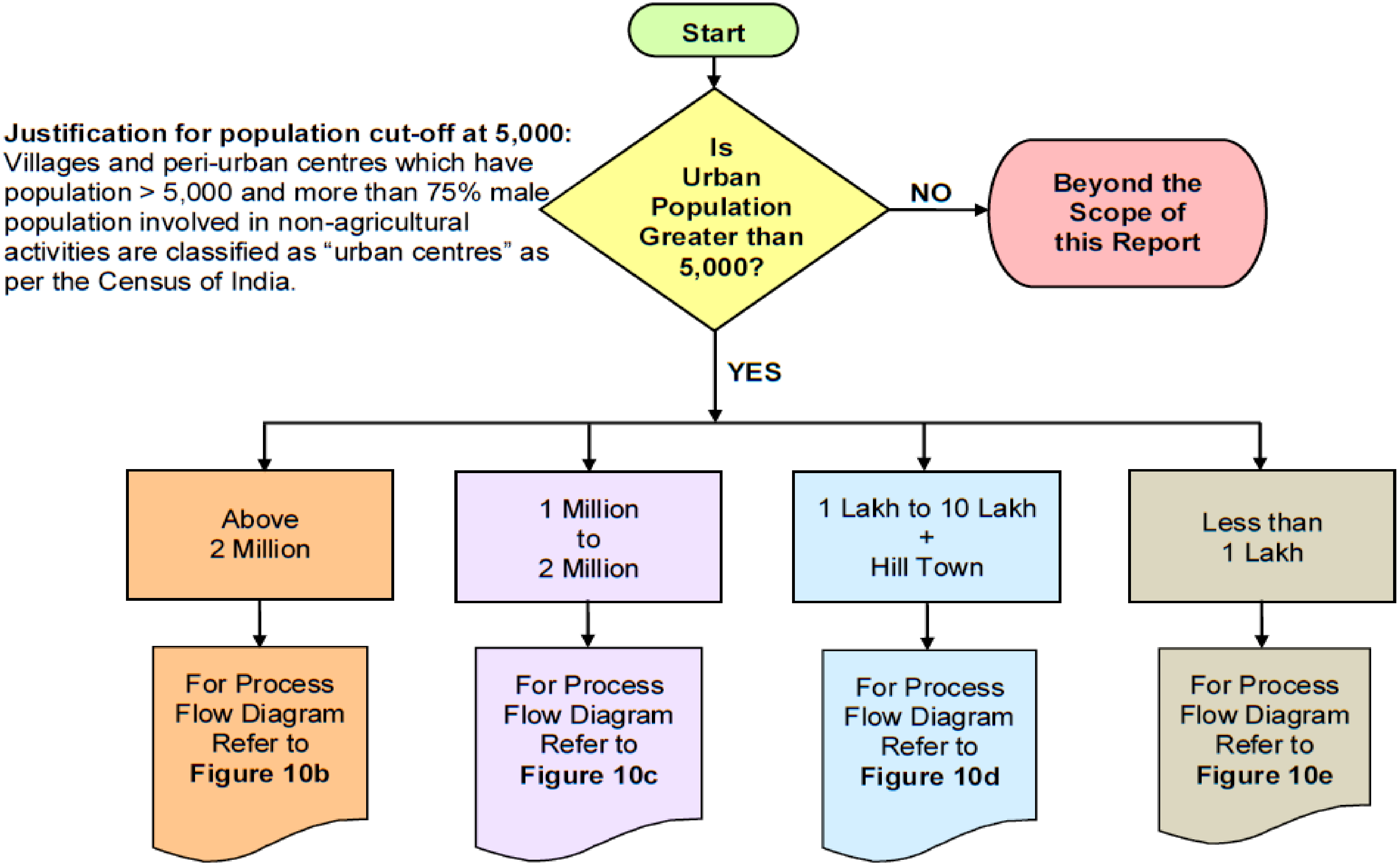
ANNEXURE

Annexure 1



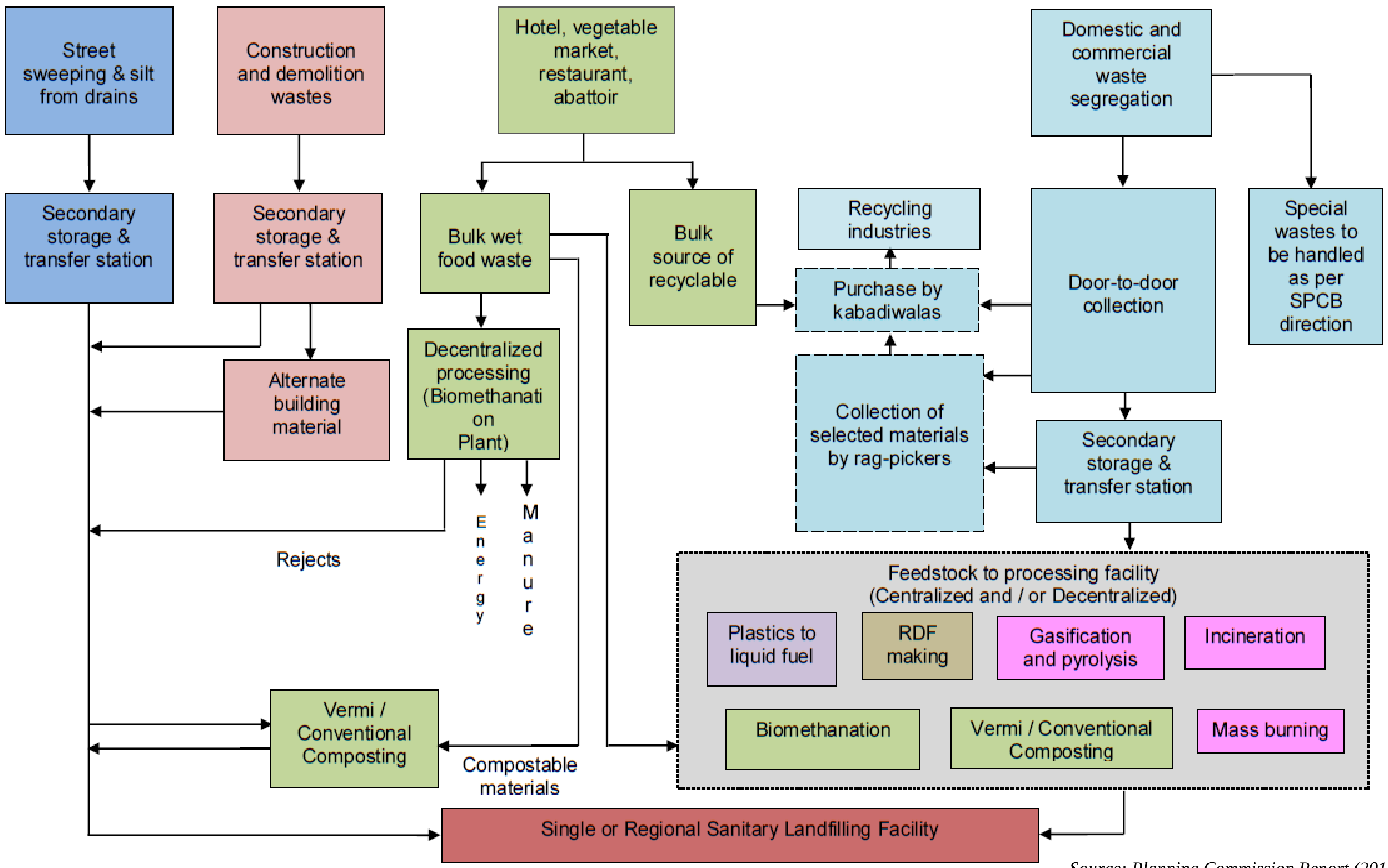
Source: Planning Commission Report (2014).

Figure AN--1 Options available for Municipal Solid Waste treatment and utilization



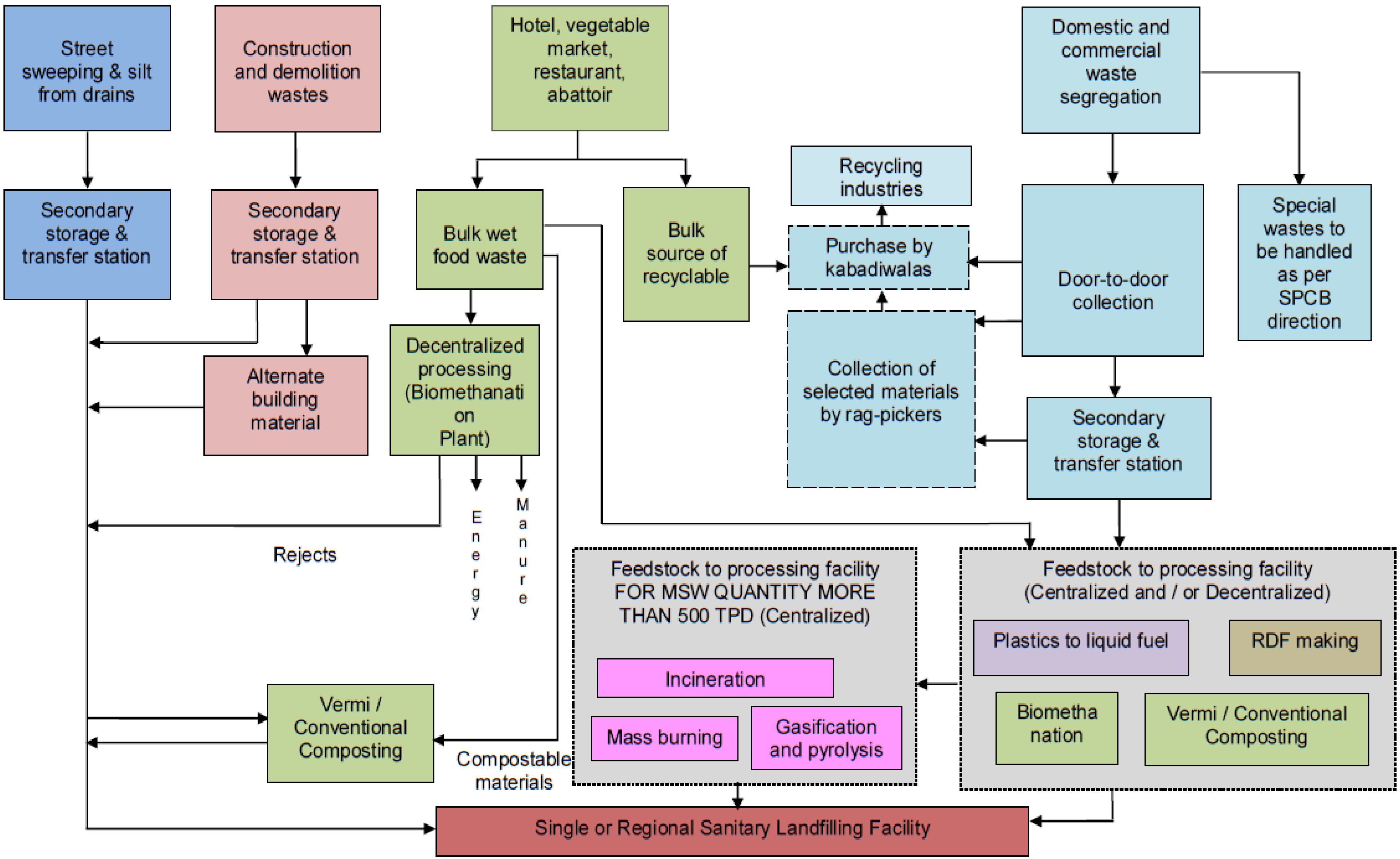
Source: Planning Commission Report (2014).

Figure AN-2 Logic Diagram for Selection of Integrated Municipal Solid Waste Management Scheme for a given Local Self



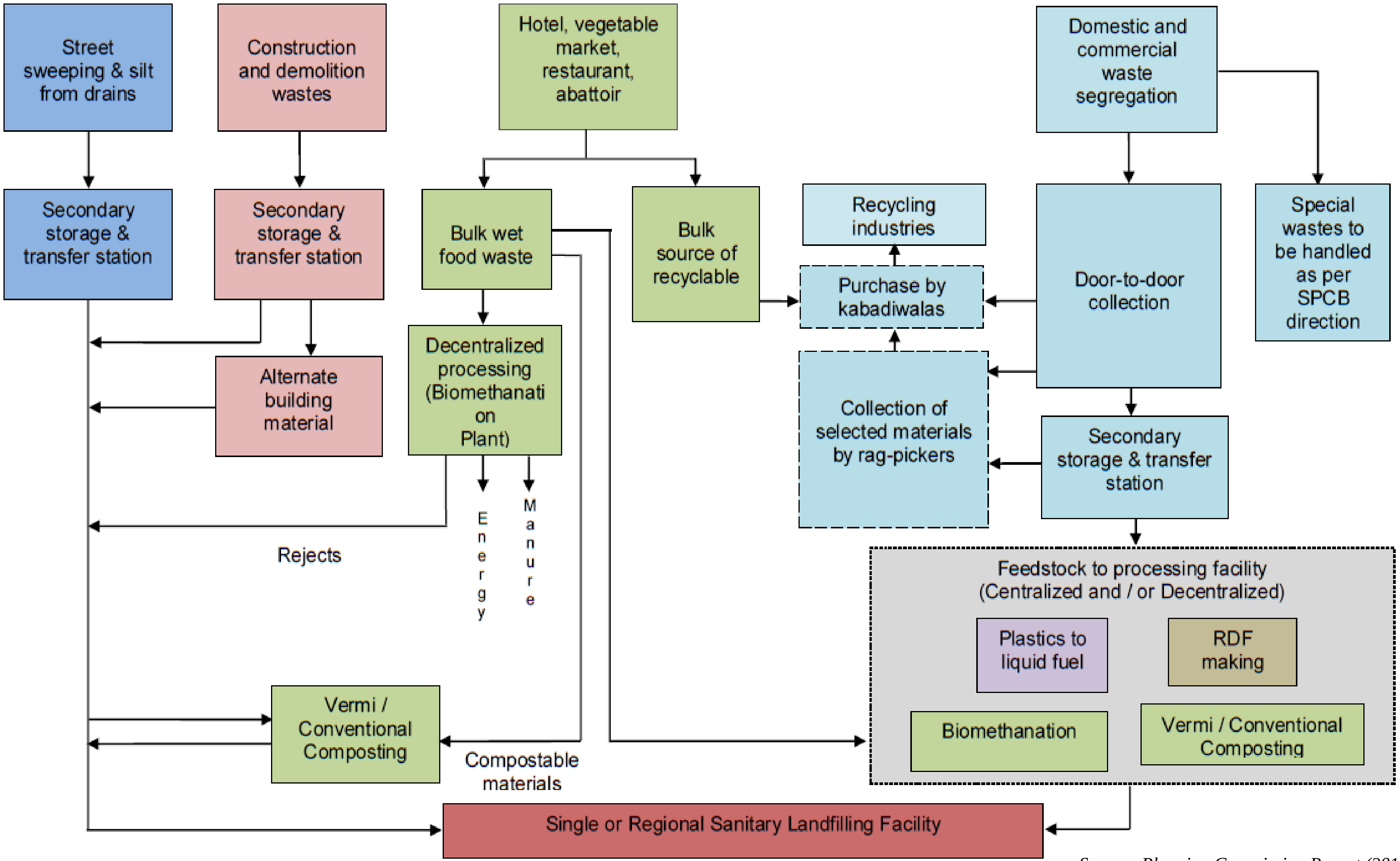
Source: Planning Commission Report (2014).

Figure AN-3 Integrated MSW Management System for the Population of more than 2 million



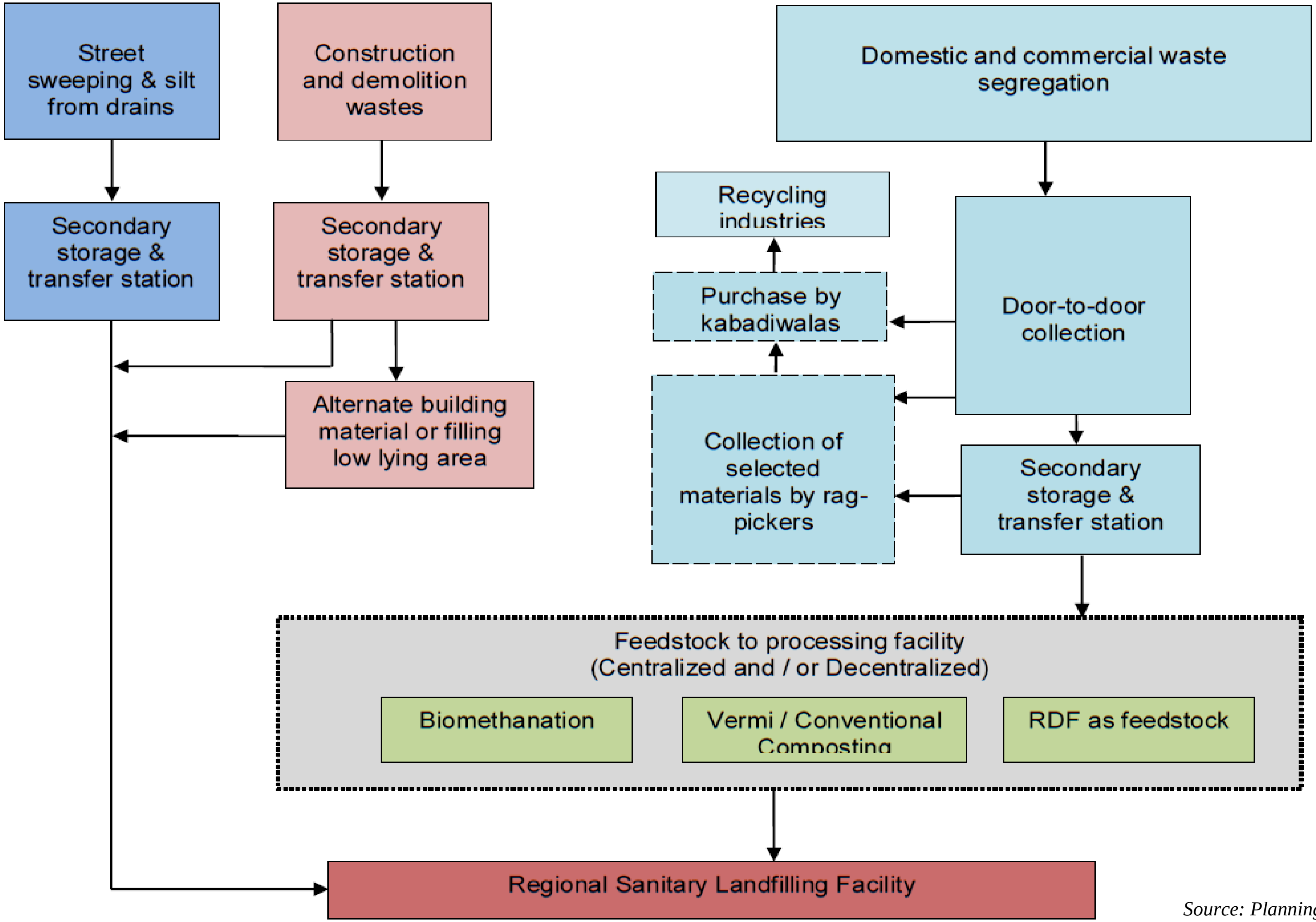
Source: Planning Commission Report (2014).

Figure AN-4 Integrated MSW Management System for the Population Ranging from 1 to 2 million



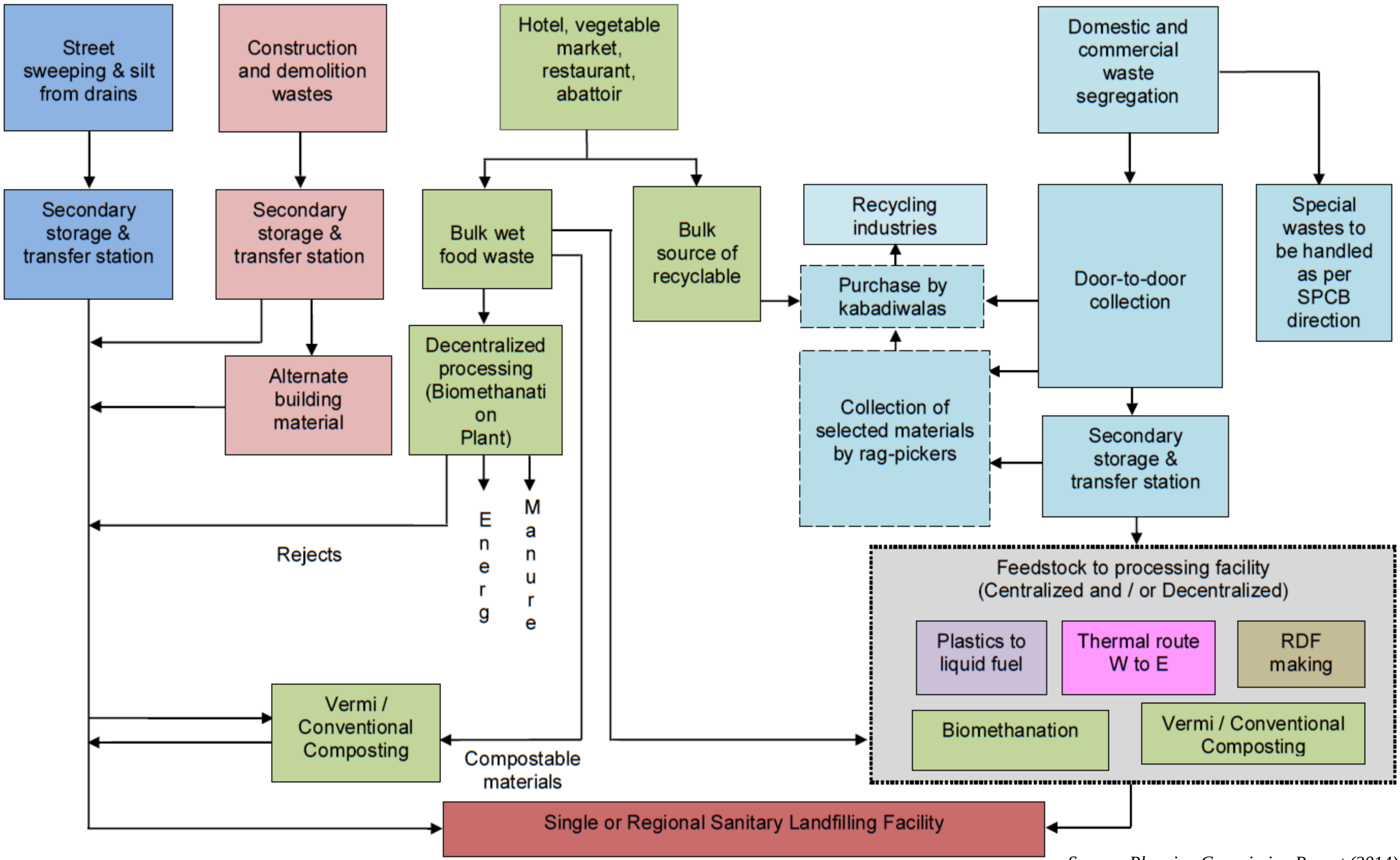
Source: Planning Commission Report (2014).

Figure AN-5 Integrated MSW Management System for the Population ranging from 1 to 10 lakh as well as for Hill Towns



Source: Planning Commission Report (2014).

Figure AN-6 Integrated MSW Management System for the Population Less than 1 lakh



Source: Planning Commission Report (2014).

Figure AN-7 General Framework for Integrated Municipal Solid Waste Management Scheme

Table AN-1 Population based Technological options to Manage MSW in Towns and Cities

Sr. No.	Population range	Waste Gen.TPD	Composition	Technological options	Minimum requirements	Value added products	Approximate cost (excluding land cost)
1	Above 2 Million	>1100 TPD	Biodegradables 35 to 50 %	IWP comprising - BM +CC+ RDF W to E plant for power, based on: gasification , pyrolysis, incineration and mass burning. RDF to cement industry Plastic to fuel oil	Segregate wet wastes at source for BM and / or CC, dry wastes to be recycled or converted into RDF as feed stock for its own power plant / cement industry or any other power plant. Inerts to be land filled RDF must be burnt under controlled condition not below 850°C	$75m^3$ of bio gas or 100 KW of electricity per 1 TPD of segregated wet wastes + 60 kg manure in case of BM , 200 kg per TPD vermi castings / CC per TPD 20 % RDF + 15 % compost. 1 MW power per 100 TPD of MSW.	Rs 5-7 Cr per 100 TPD of MSW composting + RDF Rs 15/20 Lakhs capital cost per 1 TPD for gas / electricity through Bio-methenation Rs 10 Cr per MW power plant. Rs 20 Lakh per 50kg capacity / shift catalytic conversion technology plastic waste to liquid fuel. Rs 16 Crore per 10 tonne of plastic (pyrolysis technology)
2	1 M to 2 Million	550 to 1100 TPD	Biodegradables 40 to 55 %	IWP comprising - BM +CC+ RDF W to E plant for power, where wastes exceeds 500 TPD based on: gasification , pyrolysis, incineration and mass burning. RDF to cement industry Plastic to fuel oil	Segregate wet wastes at source for BM and / or cc, dry wastes to be recycled or converted into RDF as a feed stock for large power plant and landfill the inerts RDF must be burnt under controlled condition not below 850°C	Likely output from BM, as above. 20 % RDF + 15 % compost. 1 MW power per 100 TPD of MSW.	As above

Source: Planning Commission Report (2014).

Table AN-2 Population based Technological options to Manage MSW in Towns and Cities

Sr. No.	Population range	Waste Gen.TPD	Composition	Technological options	Minimum requirements	Value added products	Approximate cost (excluding land cost)
3	1 Lakh to 10 Lakh	30 to 550 TPD	Biodegradables 40 to 55 %	IWP-BM, CC + RDF as feed stock to power plant / cement industry. Plastic to fuel oil	Segregate wet wastes at source for BM and / or CC, dry wastes to be recycled or converted into RDF as a feed stock for large power plant / cement industry and inerts to be landfilled	As above for BM + CC and RDF to be used as feed stock for power plants / cement industry likely output: (20 % RDF + 20 % Compost). 25 to 40 Litres from 50kg plastic wastes	Cost for BM, CC and RDF as above Rs 20 Lakh per 50kg capacity / shift catalytic conversion technology for plastic waste to liquid fuel. Rs 16 Crore per 10 tonne of plastic (pyrolysis technology)
4	50,000 to 1 Lakh	10 to 30 TPD	Biodegradables 45 to 60 %	BM, VC or CC RDF	Segregate wet wastes at source for BM and / or VC / CC, dry wastes to be recycled or converted in to RDF as feedstock for power plants and landfill the inerts.	As above for BM +25 to 40 Liters liquid fuel from 50kg plastic wastes	Rs 15/20 Lakhs capital cost per 1 TPD for gas / electricity through Bio-methenation Rs 7- 10lakhs per TPD for VC/CC
5	Less than 50,000	Less than 10	Biodegradables 45 to 65 %	BM VC / CC and RDF	Segregate wet wastes at source for BM, /CC, dry wastes to be recycled or converted into RDF as a feed stock and inerts to be landfilled	As above for -BM	As above
6	Hill towns	State capitals	Biodegradables 30 to 50 %	BM, CC / RDF as feed stock. Plastic to fuel oil	Segregate wet wastes at source for BM / CC, dry wastes to be recycled and landfill the inerts. Dry wastes to be recycled or converted into RDF as a feeder stock. Plastic waste can be converted to liquid fuel and inerts to be landfilled	As above for BM + CC and RDF to be used as feed stock likely output: (15 to 20 % RDF + 15 % compost).	As above Rs 20 Lakh per 50kg capacity / shift catalytic conversion technology for plastic waste to liquid fuel Rs 16 Crore per 10 tonne of plastic (pyrolysis technology)

Source: Planning Commission Report (2014).

Table AN-3 Tentative Capital cost estimates for processing various fractions of MSW

Sr. no	Classification of cities	No of cities	Population, % of total Urban population & GPCD*	Quantity of waste generated TPD	Waste to be treated (65%)** TPD	I Waste for W to E		II Waste to Bio-methanation		III Waste to Compost		Cost I (10/12* Cr per 75TPD)	Cost II (15Cr per 100 TPD)	Cost III (Rs.5Cr per 100 TPD)
						TPD	In %	TPD	In %	TPD	In %			
1	More than 1M	53	160M, 42%, & 550gm.	88,000	57,200	22,880	40	5,720	10	28,600	50	3,050	858	1,430
2	0.1 to 1M	415	105M, 27.9%, & 450 gm	48,000	31,200	7,800	25	6,240	20	17,160	55	1,248	936	855
3	Below 1 lakh	7467	112M, 29.7%, & 300 gm	34,000	22,100	2,210	10	6,630	30	13,260	60	354	995	665
	Total		377M, Average,& 450 gm	1,70,000	1,10,500	32,890		18,590		59,002		4,652	2,790	2,950
												# Grand Total		
												Approx. Rs. 10,392 Cr		
Add 15% on account of likely price rise during procurement over a period of 3-5 years												**1,559 crore**		
Total												**11,951 crores**		

Source: Planning Commission Report (2014).

Note: The total cost can be reduced by about 15-20% by deducting the cost of existing operational plants

The cost figures are tentative and hence the estimates could be ± 15% .

* GPCD is grams per capita per day ** This does not include 17,000 TPD (10%) recyclable wastes collected by rag pickers and 42,500 TPD (25%) of inert waste

*** 2 crore per100 TPD addition amount is proposed for segregating RDF in smaller towns