Feasibility Study for a Waste NAMA in India

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Table of Contents

List of Tables

List of Figures

Abbreviations

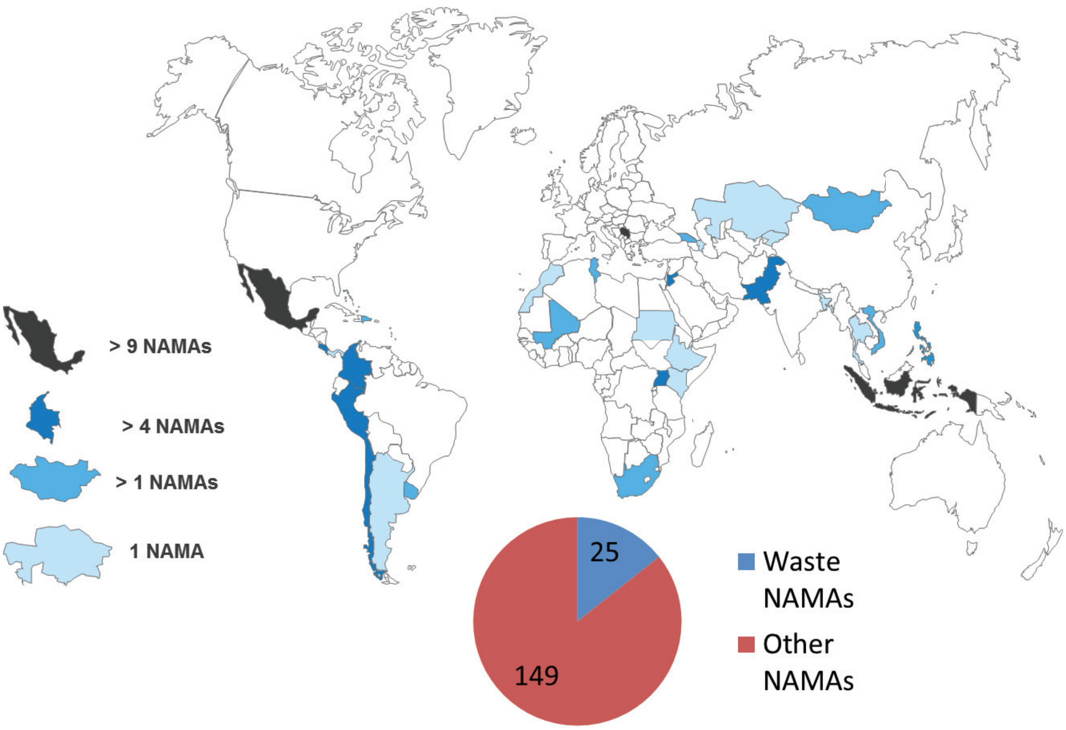
ACA	Additional central assistance
ASCI	Administrative Staff College of India
BAU	Business as usual
BBMP	Bruhat Bengaluru Mahanagara Pallike
BEE	Bureau of Energy Efficiency
CBG	Compressed Biogas
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFL	Compact fluorescent lighting
C&I	Criteria and indicators
CMA	Cement Manufacturers Association
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CPA	CDM Programme Activity
CPCB	Central Pollution Control Board
CPF	Community Participation Fund
CPHEEO	Central Public Health & Environmental Engineering Organization
DMA	Directorate of Municipal Administration
DNA	Designated National Authority
DOC	Degradable Organic Carbon
DPR	Detailed project report
DWCC	Dry waste collection centre
EPR	Extended Producer Responsibility
eq	equivalent
EUR	Euro
FOD	First order decay
GCF	Green Climate Fund
GHG	Greenhouse gas
GoI	Government of India
GW	Gigawatt
GWP	Global warming potential
Ibid.	Ibidem (in the same place)
ICA	International Consultation and Analysis
INDC	Intended Nationally Determined Contribution
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
JNNURM	Jaharwalal Nehru National Urban Renewal Mission
KCDC	Karnataka Compost Development Corporation
ktPD	kilotonnes per day
LFG	Landfill gas
MACC	Marginal abatement cost curve

MBT	Mechanical-biological treatment
MCF	Methane correction factor
MDDS	Meta Data & Data Standards
MNRE	Ministry of New and Renewable Energy
MoEF	Ministry of Environment and Forests
MoEFCC	Ministry of Environment, Forests and Climate Change
MoUD	Ministry of Urban Development
MR	Monitoring Report(s)
MRV	Measurement, reporting, verification
MSW	Municipal solid waste
MSWM	Municipal solid waste management
NAMA	Nationally Appropriate Mitigation Action
NAPCC	National Action Plan on Climate Change
NEERI	National Environmental Engineering Research Institute
NGO	Non-governmental organisation
NMM	New Market Mechanism
O&M	Operation and maintenance
PCB	Pollution Control Board
PM	Prime Minister
PPP	Public-private partnership
QA/QC	Quality Assurance/ Quality Control
R&D	Research and development
RDF	Refuse-derived fuel
RLF	Revolving Loan Fund
SB	Stabilized biomass
SD	Sustainable development
SEIAA	State Environment Impact Assessment Authority
SLB	Service Level Benchmark
SLF	Sanitary landfill
SLNA	State Level Nodal Agency
SPCB	State Pollution Control Board
SPV	Special purpose vehicle
SWM	Solid waste management
SWDS	Solid waste disposal site
TPD	Ton per day
UDD	Urban Development Department
UIDSSMT	Urban Infrastructure Development Scheme for Small and Medium Towns
ULB	Urban local body
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	US Dollar
VGF	Viability gap funding
WTE	Waste-to-energy

Executive summary

Nationally Appropriate Mitigation Actions (NAMAs) are a concept under the UN Framework Convention on Climate Change (UNFCCC) that allows India and other developing countries to harness technical and financial support as well as capacity building for greenhouse gas (GHG) mitigation while providing sustainable development benefits. There are no specific rules for NAMA development, and they can thus range from country-wide schemes to single mitigation projects. The most promising approach however is a combination of policy instruments – either incentives or regulation - with a programmatic upscaling of mitigation technologies. Given that a NAMA is voluntary, its key driver will be the harnessing of benefits for the country's national development.

Figure 1: NAMAs around the world by March 2015



To date, support for preparation of NAMAs has been provided by various sources while support for their implementation has been limited to the "NAMA Facility" that has provided close to EUR 150 million. Many stakeholders hope that the Green Climate Fund (GCF) with a capital of close to EUR 10 billion will become an important vehicle for financing of NAMA implementation.

NAMAs can also support the development of the Indian Intended Nationally Determined Contribution (INDC) to greenhouse gas mitigation in the context of the Paris Agreement, as they allow a bottom-up assessment of baseline emissions and mitigation potential that is likely to be more realistic than a theoretical, top-down assessment based on economic modelling. Even if

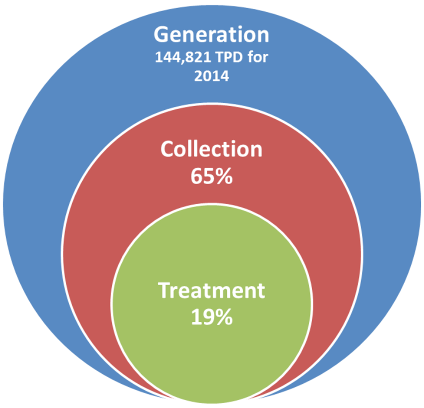
NAMA design is not finalised before Paris, information from NAMAs can play an important role in refining the INDC to eventually become the Indian Nationally Determined Contribution.

This study assesses the feasibility of a NAMA in the Indian waste management sector. It builds on a partipatory approach, with close to 50 stakeholders from all relevant groups: central, state and municipal governments, private sector entities, non-governmental organisations (NGOs) and research institutions being consulted.

Assessing the various kinds of waste that the NAMA could address, we find that the potential for mitigating GHG emissions from industrial waste is limited. Agricultural residues are an important waste category and their burning has historically generated significant GHG emissions. However, most types of residues have become a valuable resource for electricity generation in biomass power plants, with a robust market and long-term contracts. The Clean Development Mechanism (CDM) as well as generation-based incentives by the State Electricity Boards provided the incentives for over 2 Gigawatt (GW) of such plants which now use a significant share of India's agricultural residues. While the collapse of prices for CDM emission credits jeopardises continued operation of biopower plants, the overall structure of incentives and the institutional readiness on various levels of government in India is good and thus a food crop processing waste-to-energy NAMA could be established relatively easily.

Municipal solid waste (MSW) management is the most promising sub-sector due to a strong increase in waste generation with rising urbanisation. Indian MSW management (MSWM) is characterised by a low collection and very low treatment rate of MSW, while MSW generation increases rapidly with urbanisation.

Figure 2: Current status of MSWM in India



The Indian constitution allocates responsibility for MSWM to the municipalities. While various policies for MSWM exist, none of them has been able to date to significantly improve waste treatment. The very detailed regulation of the MSW Rules (2000) has only been implemented in a minority of municipalities. The key barrier is lack of funding to set up and operate modern waste treatment facilities. Large scale central government support programmes such as the Jawaharlal Nehru National Urban Renewable Mission (JNNURM) have provided funding for MSWM but it has been challenging to ensure sustainable operation of modern technologies, particularly waste-energy (WTE). The CDM has mobilised some large-scale waste treatment projects but the fall in market prices, problems with waste quality and strict measurement, reporting and verification (MRV) rules have led to a low issuance performance.

A baseline estimation of MSWM-related GHG emissions differentiated according to five city size classes shows a doubling between 2015 and 2030 to reach 40 million tons CO_2 equivalent (eq) per year, as cities grow and average waste generation per capita is higher in larger cities. These two effects lead to a particularly rapid emissions rise in the largest cities. Cities above 1 million inhabitants will contribute over half of total emissions in 2030. The baseline estimation is based on a bottom-up approach using various default parameters, mostly from the Intergovernmental Panel on Climate Change (IPCC) inventory guidance, and samples. It leads to emissions values that are 20% lower than those of the 2nd Indian National Communication to the UNFCCC; this is mainly due to lower waste generation and collection rates. The waste generation rate is derived from a sample containing 75 cities whereas for waste composition, 24 cities with CDM projects have been used. Future waste generation increase is assumed to be 1.5%. For smaller cities, landfills are assumed to be shallow. The baseline assumes that composting is the only technology applied for the share of waste treated (20%) and the same amount of waste as in 2013-14 will be treated in the future. In the future data should be collected to enable a stronger differentiation of city groups, regions and climate zones.

For the government, it is crucial to ensure that a proposed NAMA option meets the sustainable development goals. Principally, mitigation options in the waste sector have a high potential to generate environmental and health benefits. At the same time, mobilising international support requires the NAMA to mobilise mitigation and be internationally credible and acceptable. Thus, the report assesses 14 waste management and GHG mitigation technologies ("mitigation options") according to a set of criteria and indicators (C&I) derived from several sources. In a first step, consistency of the mitigation option with key national policies such as Swachh Bharat and the MSW Rules (2000) is assessed. For the second step, C&I used by government of India to evaluate CDM project proposals, complemented by C&I recommended by the UNFCCC CDM Executive Board and the Gold Standard, as well as those used by international NAMA financiers such as the NAMA Facility, the GCF and the GIZ have been considered to derive a set of 30 indicators in five categories.

Figure 3: Criteria and indicators for selection of NAMA options

Mitigation potential — 4 indicators
- Annual, 10 year, 20 year
- Abatement cost / t CO_2 eq

Economic — 14 indicators
- Bankability, leverage of private finance, balance of payments, cost savings, resource efficiency, markets for by products, direct and indirect job creation

Technology — 6 indicators
- Global tech use, tech transfer, tech experience

Environment — 5 indicators
- Complies with national env. standard on air , water and soil, respects waste hierarchy

Social — 1 indicator
- Skilled jobs

Our assessment of MSWM policies and programmes finds that principally, a sound policy framework for NAMAs exists in India. However, a number of significant barriers and challenges need to be addressed for an effective implementation of mitigation options. Key initiatives such as Smart Cities and Swachh Bharat are still in an early stage, and for other policies such as Service Level Benchmarks and the MSW Rules (2000), incentives for implementation are lacking. Municipalities are also lacking capacity for project implementation even if financial incentives exist, such as under the JNNURM.

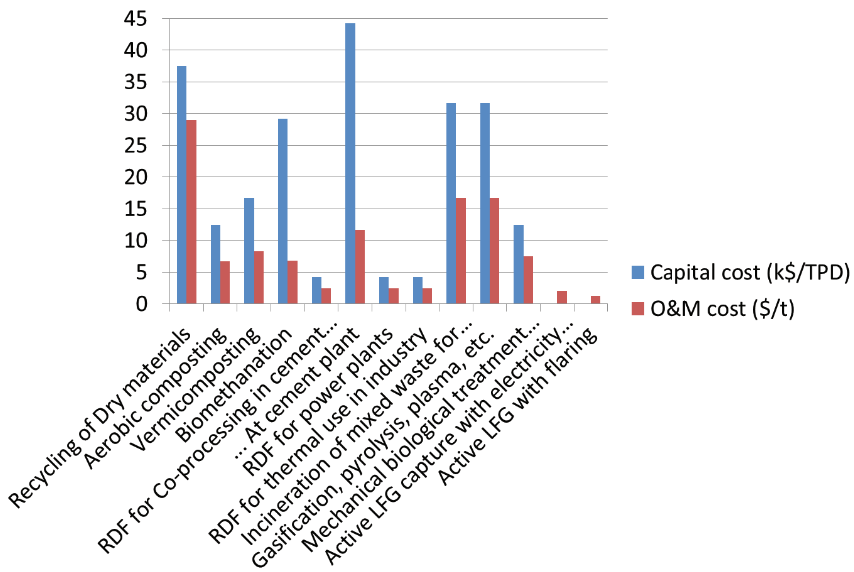
Experience with waste NAMAs around the world remains limited, as none of them is under implementation yet. Also, the NAMA Facility does not yet finance any waste NAMA. Regarding NAMA scale, significant differences can be seen – the range starts at project-based NAMAs (landfills) over the city level and reaches the national level. In Jordan, all three levels can be found. Some NAMAs focus on specific sectors / mitigation options. Only a small subset involves dedicated policy instruments. The most advanced ones combine specific mitigation options with financial incentives and have a clear institutional approach.

In India, principally the following mitigation options are available on five levels of the waste hierarchy as defined by the MSW Rules (2000):

1. Source reduction and reuse
2. Recycling of dry materials
3. Composting
    i. Aerobic composting
    ii. Vermicomposting
    iii. Biomethanation
4. Waste to energy
    i. Refuse-derived fuel (RDF) from MSW for co-processing in cement industry
    ii. RDF for power plant
    iii. RDF for thermal use in industry (other than cement)
    iv. Incineration plant for mixed MSW with electricity generation
    v. Gasification, pyrolysis, plasma
5. Landfills
    i. Mechanical Biological Treatment (MBT)
    ii. Active LFG capture with electricity generation
    iii. Active LFG capture with flaring
    iv. Methane oxidation layer

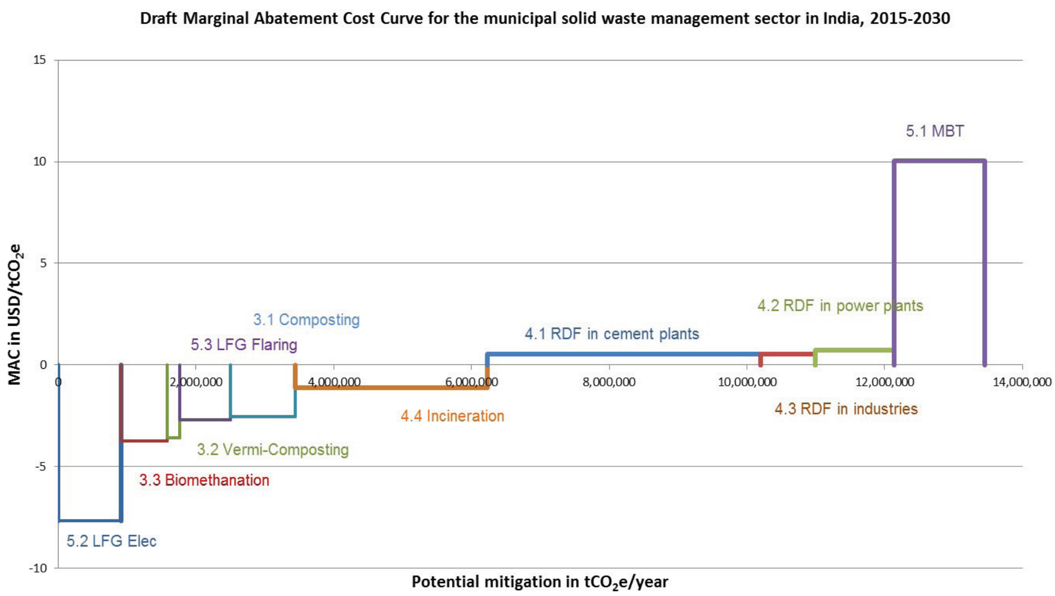
For 12 of these 14 mitigation options, an economic analysis can be performed. The summary shows that cost differentials are significant.

Figure 4: Economics of the various mitigation options



The assessment of marginal mitigation costs of 10 of the 14 mitigation options shows that even under conservative assumptions over half of the technologies have negative costs, i.e. are profitable. That shows that policy instruments based on incentives do not need to mobilise huge budgets in order to make the mitigation options economically attractive.

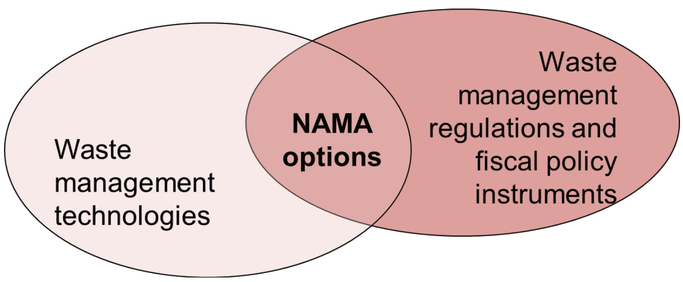
Figure 5: Marginal abatement costs of mitigation options under conservative assumptions



The mitigation options performing best with regards to mitigation costs are not necessarily those performing best with regards to the whole set of C&I. With regards to the whole set of C&I, the three best-performing mitigation options are ***RDF for co-processing in cement plants***, ***composting***, and ***biomethanation***.

Given that NAMA options can either be driven by mitigation options for which an optimal set of policy instruments is then designed, or by policy instruments that could drive a range of mitigation technologies, we also design two NAMA options driven by policy instruments - ***Waste treatment incentives with technology-differentiated results-based payments*** and ***Enforcement of mandatory segregation of waste.***

Figure 6: NAMA options as mix of mitigation options and policy instruments



Assessing the five solid waste management (SWM) NAMA options according to feasibility and readiness criteria, in the ***short term***, the most promising NAMA option is ***RDF for co-processing in cement plants.*** Our suggested range of regulatory policy instruments in this NAMA option includes:

- Guidelines allowing inter-state transfer of waste in case of co-processing of waste
- Definition of waste types applicable for all states
- Guidelines for pre-processing of waste in cement industry

Fiscal policy instruments to drive this mitigation option include

- Output based incentive through tipping fee for municipal waste treated
- Viability Gap Fund
- Revolving Loan Fund

In the ***medium-term fiscal policy instruments providing waste treatment incentives with technology-differentiated results-based payments*** should drive a wide range of mitigation options. This option would include

- Output based incentive through tipping fee for municipal waste treated
- Viability Gap Fund differentiated by mitigation option
- Single window clearance for waste management projects

The above technology-driven and policy-driven NAMA options would be the initial routes suggested.

Next to the most promising short-term, technology-driven NAMA option described above, the other two most relevant NAMA options identified are ***Composting and vermicomposting*** and ***Biomethanation***. As above, these mitigation options would be accompanied mobilized by a set of policy instruments and capacity building measures. Potential regulatory policy instruments completing the NAMA option ***Composting and vermicomposting*** include facilitation of land identification & acquisition, quality standards & label for compost and an uptake requirement of unsold compost by forest / agricultural department. Fiscal policy instruments could be include a Viability Gap Fund, a government-specified price for purchase of compost and an output-based incentive through in the form of a tipping fee for municipal waste treated. A capacity building mix could comprise of training of auditors to check quality standards, capacity building of thetraining of actors in the informal sector and training of vermicomposting operators. For the NAMA option ***Biomethanation*** regulatory policy instruments could be the enforcement of mandatory segregation of waste at household level and the facilitation of land identification & acquisition. Potential fiscal policy instruments are an output-based incentive through tipping fee for municipal waste treated, a Viability Gap Fund and a feed-in tariff for electricity generated from biogas. Capacity building measures could include a training of operators and as well as research and development for generation of biogas by "unusual" waste types.

We stress that this is a preliminary assessment, subject to confirmation in the next phase of SWM NAMA development. The suggested approaches require political will to enforce certain regulatory policy instruments while providing budget to cover costs of the incentives. If India would be able to harness international financing, given the low mitigation costs, the budgetary burden would likely be relatively low. As a first step, the Ministry of Environment, Forests and Climate Change (MoEFCC) should create a NAMA cell that would administer the MRV system for all NAMAs, not only the SWM one. MRV of the SWM NAMA should be based on conservative default values for baseline emission parameters as well as for mitigation technology performance.

Introduction

1

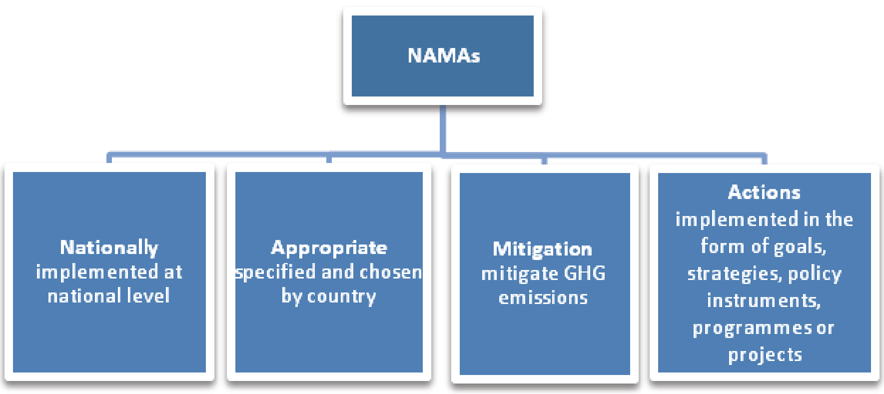
Solid waste management worldwide is responsible for significant emissions of GHG , particularly methane, which especially in the short-run contributes intensely to global warming[1].

The SWM sector in India has a significant potential for GHG mitigation. This report assesses the possibility of developing a NAMA for this sector.

The concept of NAMAs has emerged in the negotiations under the UNFCCC since 2007. NAMAs are voluntary and not tied to any formal commitments of national governments regarding mitigation. Principally, NAMAs can be of unilateral or supported nature – in the former case the government organises the financing of the NAMA from domestic resources while in the latter case resources for technical assistance as well as implementation of mitigation technologies are at least partially provided by multi- or bilateral sources of financing. It should be noted that to date, only few NAMA proposals have received significant support for implementation – mainly through the Anglo-German "NAMA Facility" that has allocated EUR 148 million between 2013 and 2015. Only 10% of proposals to the NAMA Facility have been funded, though. Traditionally, bilateral NAMA support has focused on feasibility studies. However, in the future funding from the GCF may become available for NAMA implementation given it has been filled with USD 9.6 billion for 2015-2018. The procedures for accessing GCF grants and loans remain to be defined. Whether NAMAs might be able to receive credits from market mechanisms depends on the course of negotiations under the UNFCCC.

National appropriateness is captured by whether a mitigation option is aligned with the priorities of national development and provides sustainable development benefits. Mitigation is achieved by implementation of projects on the ground using low-emitting technology, and driven by policy instruments that incentivise use of low-emission technology or remove barriers to its implementation (see Figure 7). Both aspects have to be assessed via measurement, reporting and verification – a critical component of a NAMA.

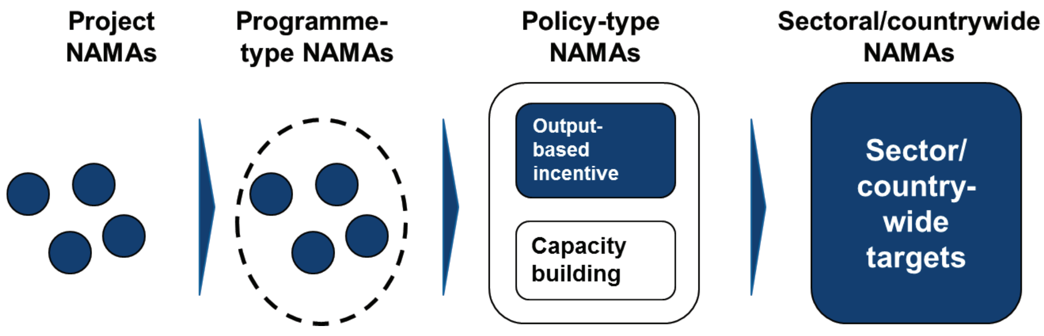
Figure 7: NAMAs – Nationally Appropriate Mitigation Actions



1 While over a time horizon of 100 years, methane is 25 times more potent than CO_2, over a time horizon of 20 years, its warming contribution is 70 times stronger. This difference is due to methane's short average atmospheric half-life of 12 years.

In contrast to mechanisms of the Kyoto Protocol such as the CDM, there are no modalities and procedures for NAMAs defined on the international level. Broadly it can be said that any policy, programme or group of projects that reduces GHG emissions (directly[2] or indirectly[3]) below business as usual (BAU) is in principle eligible to be a NAMA (see Figure 8).

Figure 8: NAMA types



Governments that would like to receive technical or financial support for NAMA implementation might have to specify how the NAMA performs with respect to certain criteria and indicators, as the financiers may want to ensure that their contribution leads to robust and efficient mitigation. The financiers' criteria may not be consistent with the domestic sustainable development criteria set and therefore government will need to assess which sources of support should be prioritised (also see discussion in Section 3 below).

NAMAs can play an important role in the context of the elaboration of the INDCs that all countries are developing in preparation for the Paris Conference of the Parties to the UNFCCC in December 2015. INDCs comprise contributions to mitigation, possibly also to adaptation and finance. While many countries develop their INDCs in a "top-down" fashion through economic modelling, a careful assessment of the mitigation potential of each sector in a "bottom-up" fashion is important to prevent an overly optimistic evaluation of the mitigation potential. If a NAMA exists in a sector, an emissions baseline and estimate of the mitigation potential will have been developed. Also, barriers to the mobilisation of the potential will have been identified as well as ways to overcome them. Therefore, an INDC based on a multitude of NAMAs is likely to be much more realistic than a theoretical modelling exercise. Even if a country is unlikely to finalise all its NAMA ideas before Paris, they remain useful in the context of definiting mitigation contributions. The transition from the INDC to the actual Nationally Determined Contribution is likely to take several years and thus the final shape of the contribution can then be based on the NAMAs developed during this period.

In Section 2, this feasibility study provides an overview about the status of SWM in India and discusses why MSWM is the most promising approach for a NAMA. Section 3 focuses on the identification of sustainable development C&I. These are then applied in Section 4 for prioritisation of policy instruments as well as MSWM technologies ("mitigation options"). An analysis of the economics of mitigation options that achieve a minimum performance with regard to the criteria follows in Section 5. Section 6 develops a Marginal Abatement Cost Curve (MACC) for the mitigation options identified in Section 4, applying the economic parameters for the technologies assessed in Section 5. An actual prioritisation of policies and mitigation options is undertaken in Section 7; it takes into account stakeholder inputs received through a series of consultations undertaken between November 2014 and March 2015. In Section 8, we then provide an overview

2 Direct GHG emission reduction is achieved by policy instruments that lead to the implementation of mitigation technologies.

3 Indirect GHG emission reduction can be triggered by capacity building or information provision such as data collection.

of MRV approaches that could be applied for the prioritised NAMA options. Section 9 develops a set of three technology-oriented and two policy-instrument driven NAMA options. Section 10 sums up the key results of the study and highlights the two most promising NAMA options – RDF for the cement sector, and waste treatment incentives with technology-differentiated results-based payments. These options need to be further refined in order to develop a detailed blueprint for an SWM NAMA.

The key characteristics of the SWM NAMA as developed in this feasibility study are described in below table.

Table 1: General elements of the SWM NAMA

Item	Description
Sector	Waste management
Sub-sector	Municipal Solid Waste Management
NAMA boundary	Entire country
Measures and activities with direct impact on GHG emission reduction	Policy instruments incentivizing low-GHG waste management mitigation options, preferably: - Co-processing of waste in the cement sector - Composting - Biomethanisation Key evisaged instruments are output-based payments and enforcement of regulation to segregate waste at source to enable effective treatment of the different waste fractions
Measures and activities with indirect impact on GHG emission reduction	Capacity building of institutions enforcing SWM regulation
NAMA type	Unilateral and supported
Type of support required	Technical assistance, capacity building, technology transfer, results-based financing

2 Description of the current status of SWM in India

2.1 SWM ON VARIOUS LEVELS AND SOLID WASTE TYPES APPROPRIATE FOR NAMA DEVELOPMENT

India is the second largest country in the world by population after China. Population reached 1,210 million people counted at the last census in 2011 (Ministry of Home Affairs, 2011a), and 1,286 million have been estimated for 2015. With population growth and production growth, waste generation is rising. Solid waste is generated by households and industrial production as well by agricultural processes. Hence solid waste can be categorized into industrial waste, agricultural waste and municipal solid waste. Below, we discuss which waste types are appropriate for the development of a NAMA.

Industrial waste is categorised into hazardous and non-hazardous waste. Hazardous waste in particular includes products that are explosive, flammable, irritant, harmful, toxic, carcinogenic, corrosive, infectious, or toxic to reproduction. As per data from the Central Pollution Control Board (CPCB, 2011) in India 41,523 industrial sites generate 7.9 million tons of hazardous wastes every year, of which 42% are characterised as landfillable, 7.6% as incinerable and 50.4% as recyclable. Industrial hazardous waste has a low content of organic degradable waste and hence its disposal generates negligible methane emissions. The potential for generating energy through incineration is rather limited. Moreover, hazardous industrial waste management is already quite advanced, as CPCB (2010) provides detailed guidelines for its processing and disposal so that it does not pollute air, water and soil.

Non-hazardous industrial waste can be categorised into inorganic and organic waste. India generated around 290 million tons of inorganic waste from industrial and mining sectors per year (Pappu et al., 2007). The major industrial non-hazardous inorganic solid wastes are coal combustion residues, bauxite red mud, tailings from aluminum, iron, copper and zinc primary extraction processes. Methane emission from inorganic waste will be negligible due to absence of degradable organic component.

Industrial organic solid waste is produced by industries such as textile manufacturing industries, food processing industries, animal husbandry industry, dairies, slaughterhouses, tanneries, sugar manufacturing industry, fermentation industry, food industry and agriculture based industries (Patwardhan, 2013). Bulk organic waste generated from slaughterhouses are used as livestock feed whereas small quantities of slaughterhouse waste generated from distributed shops are mostly mixed with MSW. Other types of organic waste are generated in a scattered manner and have limited GHG emission potential due to the aerobic decay, and are thus not covered under the NAMA.

Organic waste from industries like the fermentation industry, the textile industry, dairies, pulp and paper industries generates waste in liquid or semi liquid form (sludge). The sludge is left to decay aerobically in open lagoons before being used as compost. Emissions from this type of liquid organic waste is not covered under the NAMA.

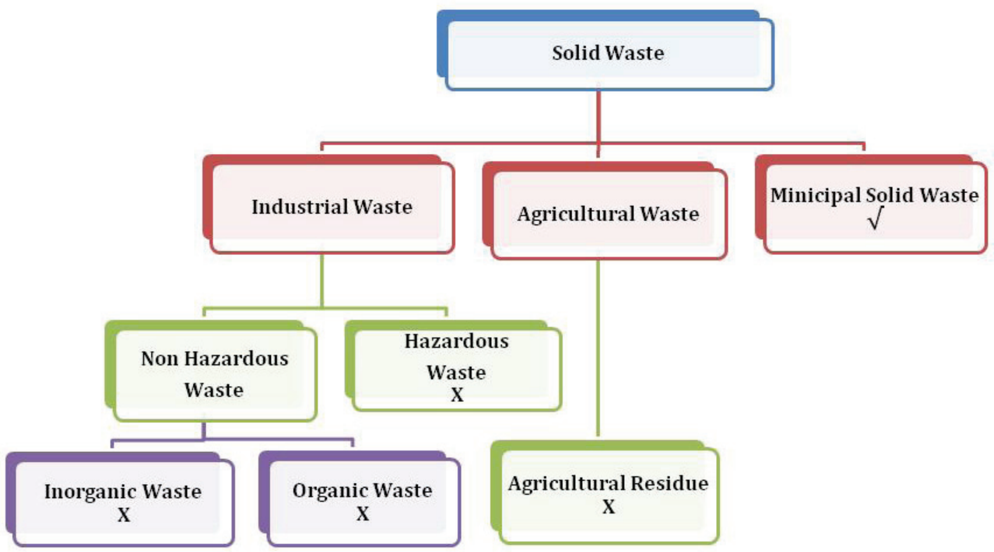
India's economy still largely depends upon agriculture. Estimations of the volume of agricultural residues range from 300 million tons per year in 2012 (Awalgaonkar et al., 2014) to 620 million tons per year in 2008-09 (Jain et al., 2014). GHG emissions from open burning of agricultural residues have resulted in 7 million tons of CO_2 eq in 2000 (Ministry of Environment and Forests, 2011). Organic waste generated from food processing industries, sugar industries and agriculture-based industries has good calorific value (around 2,000 to 3,500 kcal/kg) and can be used as fuel. The Ministry of New and Renewable Energy's (MNRE) Biomass Power and Cogeneration Programme in India has promoted the use of food processing and agricultural wastes such as bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, saw dust for grid power generation (MNRE, 2012). Apart from government programmes, CDM has also mobilised the use of food processing wastes in thermal and electrical energy generation projects in India in an unprecedented fashion. As per April 2015, India had large numbers of registered CDM projects using organic industrial solid waste (UNEP DTU, 2015a):

- 181 power plants totaling 1.2 GW using agricultural residues other than bagasse, having achieved issuance of 11 million certified emission reductions (CERs)
- 51 power plants totaling 0.8 GW using bagasse, having achieved issuance of 4.6 million CERs

As a result of this development, a thriving market for solid agricultural residues has developed, which has eliminated disposal on the fields for the key categories. Thus, food crop processing wastes are mostly utilised for electricity generation and only a limited amount is left to decay. Hence food crop processing waste is not further considered under a SWM NAMA. It should however be noted that if the CDM market does not emerge from its currents doldrums, a food crop processing waste-to-energy NAMA might be a good instrument to prevent closure of the plants developed under the CDM.

The assessment of the appropriateness of covering various solid waste types is summarised in Figure 9. In this study, we focus on MSW.

Figure 9: Types of solid waste considered in NAMA study (√: considered, X: not considered)



Due to rapid economic growth, India's urban population has been increasing from 286 million in 2001 to 377 million in 2011 (Ministry of Home Affairs, 2011a) and it is expected to reach 590 million by 2030 (McKinsey, 2010). The amount of MSW generated by Indian urban population in cities of equal or more than 20,000 inhabitants has also increased from 81.6 kilo tons per day in 2001 to 149.4 kilo tons per day in 2014. According to CPCB (2014), 92.8 kilo tons per day of MSW was collected in urban areas (around 65% of all waste generated in urban areas), and only 27.1 kilo tons per day (around 19% of all waste generated) was processed or treated by using mitigation options like composting or vermicomposting or waste-to-energy plants. The remaining quantity of collected waste is dumped into solid waste disposal sites (SWDS) without any treatment.

Management of such a huge amount of MSW in the country has emerged as a severe problem not only because of the environmental, hygienic and aesthetic concerns but also because of the sheer quantities generated every day that need to be collected, transported, treated and disposed. In addition, enormous pressure is being built on the limited yet essential resource land. The Ministry of Finance (2009) estimates a requirement of more than 1400 sq. km of land for solid waste disposal by the end of 2047 if MSW is not properly handled.

In India, SWM falls within the purview of the state government. The details on the roles and responsibilities of key players involved in the SWM chain are provided below in this section and the details on regulatory issues are provided in Section 4. The activities are delegated to Urban Local Bodies (ULBs) through state legislations. MSWM is a part of public health and sanitation, and is delegated to the Civic Bodies for execution as per the respective Corporation/Municipal/Panchayat Acts. Central government provides rules and advisory for solid waste management in India. The MSW Rules (2000) (MoEF 2000)[4] contained directives for all ULBs to establish a proper system of waste management and provide annual report to State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) and in turn SPCBs/PCCs will forward annual reports to the CPCB.

In 2013-14, out of total 3,839 ULBs, only one third, i.e. 1,314 ULBs have reported the status of the implementation of the MSW Rules (2000) to the CPCB (CPCB, 2014). Hence major non-compliance which could be ascribed to inadequate funds and technical capacities at the municipal level exists even after 15 years of the notification of the MSW Rules (MoUD and CPHEEO, 2014).

Most Indian cities lack waste treatment facility or sufficient capacities of those and therefore most of the waste is disposed of in an unsustainable manner leading to environmental hazards with respect to land, water and air pollution (Kansal, 2002) as well as considerable human health risks.

ULBs are facing several difficulties like budget constraint and lack of capacity in executing solid waste management projects. Such difficulties are paving the way to building waste-energy (WTE) plants, biological treatment solutions and landfill sites through private participation or through involvement of other stakeholders like NGOs.

The Government of India (GoI) has invested significantly in SWM projects under the 12th and 13th Finance Commission in form of grants and funds under the Jawaharlal Nehru National Urban Renewable Mission (JNNURM) and the Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) (MoUD and CPHEEO, 2014). According to the 12th Finance Commission 2005-10 report, GoI has provided USD 410 million (INR 25 billion) as grant in aid to states for ULBs specifically for SWM through public-private partnerships (PPPs) (Finance Commission India, 2004).

As on August 8, 2014, 46 MSW projects entailing an investment of USD 350 million (INR 21.1 billion) had been sanctioned under the Urban Infrastructure and Governance component of the

4 MoEFCC has released the draft Solid Waste Management Rules 2015, on website for comments and stakeholder consultations on rules is undergoing till May 2015.

JNNURM. The additional central assistance (ACA) commitment towards these projects stood at USD 187 million (INR 11.23 billion). Under the UIDSSMT component, 67 MSW projects worth USD 85 million (INR 5.11 billion) have been sanctioned as on March 31, 2014. The ACA commitment towards these projects stood at USD 70 million (INR 4.21 billion). Further, at least eight projects costing in excess of USD 316 million (INR 19 billion) are under implementation on a PPP basis, at the state level (India Infrastructure Research, 2014).

Despite this significant investment, the present scenario of waste management is not very encouraging in India and it requires immediate attention to solve this problem. Proper SWM will not only reduce the pressure on eco system and human health but it will also minimize the contribution to climate change.

As per an estimate, the waste disposal at SWDS of urban centers with more than 20,000 inhabitants in India has resulted in emissions of 18.6 million tons of CO_2 eq in 2014 and is expected to reach 41.09 million tons by 2030, an increase of more than 100% in the next 15 years (see Section 2.2 for a detailed discussion).

Source(s) of MSW

As per MSW Rules (2013), MSW includes the commercial and residential waste produced in municipal or notified areas in either solid or semi-solid form without industrial hazardous waste, e-waste and including treated bio-medical waste (MoEF, 2013). However in practice, MSW usually contains food wastes, paper, wood, textiles, plastics, metals, glass, street sweepings and general wastes from parks. Sometimes other types of wastes like construction and demolition (C&D) waste, hazardous waste (e.g. batteries) and e-waste (from electronic goods) are also mixed with MSW.

In India, stray animals like cows, dogs, pigs and buffalos on roads consume food wastes thrown by residents in open areas. In many cases, residents prefer to feed leftover cooked foods like roti, vegetables, meat to animals rather than disposing it at dump sites.

Street sweepings are also collected in community bins but in many cases it has been observed that dry part of street sweepings are burnt in open to reduce its weight, leading to severe air pollution problems in the cities.

Given the low collection coverage, considerable quantities of waste are dumped into nearby barren land, low lands or in the streets, or are burnt in the open by households or communities in areas that are not covered by the municipal collection service. It is estimated that about 2% of uncollected wastes are burnt in the open and an estimated 10% of the collected MSW is openly burnt at the SWDS releasing harmful pollutants to the atmosphere (Annepu, 2012). A considerable fraction of organic waste lying in street or at landfill sites is also eaten by stray animals. Only 30% of collected waste (~19% of all waste generated) is treated and the remaining quantity is dumped into SWDS leading to health and environment related problems.

As per CPCB (2014), Maharashtra, Uttar Pradesh, Tamil Nadu and Andhra Pradesh together generate over 50 % of the total MSW generation in the country. These are the states with high levels of urbanisation (Appendix 1).

At the city level, there are 53 cities above 1 million inhabitants (Ministry of Home Affairs, 2011b) and they have generated more than 40% of the total waste generated in India in 2011. Cities with more than 1 million inhabitants are expected to be 68 (McKinsey, 2010) by 2030 and they are expected to generate more than 50% of the total waste generated in India (see Section 2.2).

Waste generation rate and its composition

Waste generation rates vary across urban cities from 349 grams per capita per day in smaller cities with population below 100,000 to 485 grams per capita per day in bigger cities with population more than 5 million (see Table 11).

Waste composition also widely varies across India. The composition varies with life style and social status of the populations in urban cities (Sharholy et al., 2007). The study highlights that the biodegradable waste (including food and garden waste) makes the major proportion of waste (varying from 65% to 77%, see Section 2.2) that goes to the disposal site. This can be mainly ascribed to the fact that a lot of vegetables are being produced, consumed and disposed of in the Indian scenario. Waste generated from larger cities has a lower percentage of organic waste compared to smaller cities. This is because more pre-processed products are consumed in the bigger cities compared to smaller cities.

Collection and transport of waste

In many Indian cities door-to-door waste collection exists in which waste is collected from households. However, the same is not possible where access to household is difficult due to a high population density, narrow lanes and thus limited access to households. In such cases, waste is left to decay in the open or is collected by corporation staff infrequently .

Wastes are generally collected with small vehicles (auto trailer) or thela/rhedri (hand pulling rickshaw) by corporation staff or private contractors. Usually these vehicles do not have separate chambers for dry and wet waste. Private contractors make some effort to separate recyclable parts from the waste to make extra money.

Waste collected from households and other sources is carried to a collection point. These collection points show poor sanitary conditions and pose health hazards to the workers and waste pickers. At these collection points part of the wet waste is eaten by stray animals and recyclable parts are collected by waste pickers. In some cities, NGOs are involved in the collection of recyclables through the service of waste pickers.

These collection points are also referred to as transfer stations as waste from these collection points is transferred to trucks. These trucks are owned and maintained by municipal corporations or private contractors. These trucks collect waste from collection centers generally in the afternoon and carry the waste to dump sites or waste treatment facilities for processing of waste before disposal.

There is no organised segregation of waste at source due to a lack of awareness and willingness among households. Only few isolated pilot projects on separate waste collection from a limited number of households exist. In some cases (e.g. in Bangalore), it has been found that recyclable wastes are separated from wet wastes during collection by corporation staff.

Waste from other sources like shops, slaughter houses, markets, gardens, parks, offices etc. is collected separately. In some cases, biomedical wastes are also mixed with MSW.

Recycling

In India, it is general practice by households to segregate high worth recyclable materials (like newspaper, plastic bottles, glass, metals etc.) and sell it to Kabariwalas (itinerant waste buyers) on direct payment. Recyclables of less value (torn paper, plastic pieces, glass pieces, metal pieces etc.) are mixed with MSW. The recyclable component in MSW varies from 15% to 26% in waste collected from households (see Section 2.2).

Recycling in India is largely carried out by the informal sector. The informal sector consists of waste pickers, itinerant waste buyers, dealers and recycling units. Waste pickers constitute the largest population in the informal sector (Annepu, 2012). Beside this, there is some organized or formal recycling activity under the coordination or supervision of the disposal site operator, e.g. Sahaas is engaged in recycling of waste in Bangalore.

The recyclables collected by waste pickers are sold to small, medium and larger dealers. The dealers sell it directly or through large scale dealers to recycling units.

As per an estimate, the informal sector recycles 20% of the recyclable components of MSW collected in India (Annepu, 2012). It has to be mentioned that this number excludes the amount of waste recycled from MSW prior to collection, which is commonly not accounted for and can amount to four times the quantity recycled from officially collected waste. This implies an estimated overall recycling share of 56% of recyclable waste generated (Annepu, 2012). The waste management hierarchy also recognises material recovery from waste in the form of recycling as one of the most prioritised manners of waste handling. But under the current scenario, i.e. with technical and economic limitations of recycling, product design, inadequate source segregation and inadequate market for sorted waste, most of the MSW generated in India ends up in landfills.

It is recommended for the following phase to investigate this field and the actual recycling quantities further, particularly if recycling is to be chosen to be a NAMA option.

Treatment of waste

There are 645 compost/vermicompost plants and 71 waste-to-energy plants (RDF/pellet - 18, Biogas plants - 41 and power plants - 13) set up by ULBs for treatment of waste (CPCB, 2014). However, most of the treatment facilities have encountered severe problems during operation (Annepu, 2012), or operate at throughputs far below their capacity. This has led to less treatment of waste resulting in respectively higher waste disposal to SWDS sites.

Disposal of waste

As per CPCB (2014), more than 80% of waste generated (117.2 kilo tons per day) is dumped to SWDS sites without any treatment. India had only 69 sanitary landfill sites constructed and operational in 2013-14 (CPCB, 2014), hence most of the MSW waste is dumped on open land or at unsanitary landfills (open dump sites).

Open dumping of waste or unsanitary landfill sites lack of monitoring of the site. Stray animals and birds feed on the waste. Leachate or methane collection systems are absent and the waste is exposed to natural elements such as heavy rain or strong winds. Even the sanitary landfills are not properly managed which results in landfill fire, leachate problems, methane emissions etc.

Only a small share of cities is practicing leachate collection and treatment, and there are only very few projects of landfill gas recovery at dump sites or landfills. The frequency of applying earth cover on waste (daily or periodic cover) is not known (Annepu, 2012). However, it is known that earth cover is partly provided in a few cities including Mumbai, Kolkata, Chennai, Ahmadabad, Kanpur, Lucknow, Coimbatore, Nasik, Vadodara, Jamshedpur, Allahabad, Amritsar, Rajkot, Simla, Thiruvananthapuram, and Dehradun (Kumar et al., 2009).

The following table shows operating and planned landfill sites across India:

Table 2: Status of landfill facilities in India (CPCB, 2014)

Reported during 2013-14	Number
Landfill sites constructed	69
Initiative taken for construction of new landfill sites	164
Landfill sites identified	774

ULBs from smaller cities have not yet identified landfill sites in accordance with MSW Rules (2000). In larger cities like Delhi, existing landfill sites have been exhausted and the respective local bodies do not have resources to acquire new land. Such lack of landfill sites decreases MSW collection and treatment efficiency.

History of Indian SWM Policies, programmes & initiatives

This section provides a snapshot of the SWM related policies and programmes at the national and state level (more details provided in Section 4) which aim at providing an enabling environment for a strong policy framework for SWM in India. In addition, there are many initiatives at the local level in different parts of the country which provide useful learnings for implementation of similar cases.

Table 3: Key policies, programmes & initiatives in SWM sector in India

National level policy and programmes

Snapshot of the chronological sequence of policy, programmes, funding initiatives in waste sector of India:

1994-95	Strategy paper by NEERI
2000	MSW (Management and Handling) Rules (2000)
2000	CPHEEO Manual on MSW Rules (2000)
2005	Report of the Technology Advisory Group
2005-12	40 MSW projects of INR 21.86 billion sanctioned so far – 65 cities covered
2005-12	51 MSW projects of INR 3.27 billion sanctioned so far – 632 cities covered
2005-10	12th Finance Commission – INR 25 billion for 423 Class-I cities
2006	Strategy & Action Plan for the use of compost in cities
2007-12	11th Five Year Plan-Working Group recommended an investment of INR 22.1 billion for MSWM
2008	National Urban Sanitation Policy, which broadly covers aspects of urban sanitation, with a specific focus to remove open defecation in the cities and towns and re-orienting institutions for developing and deploying city-wide approaches to sanitation, covering all its aspects
2008	Service Level Benchmarking in MSWM
2010	National Mission on Sustainable Habitat
2010-15	13th Finance Commission established standards for delivery of essential services
2011	Renewal of 500 urban habitations as per the plans stated by MoUD
2011	Plastic Waste (Management & Handling) Rules
2013	Draft Municipal Solid Waste (Management & handling) Rules
2014	Development of 100 smart cities

A detailed review of some of the above listed policies and programmes is done in Section 4.

Examples for other initiatives

- **Plans to augment waste treatment capacity –** Several ULBs like Trimbakeshwar Municipal Council, Ponda Municipal Corporation and Tiruchirapalli City Corporation have taken steps to increase solid waste treatment capacity at the city level.
- **WTE projects –** Projects have been taken by Bruhat Bangalore Mahanagara Palike (BBMP), Rajkot Municipal Corporation and Municipal Corporation of Greater Mumbai (MCGM) to generate energy from solid waste.
- **Increase in collection efficiency –** e.g. Mangalore City Corporation has launched door-to-door collection facility.
- **Technology initiatives –** Delhi Waste Management has started deploying a Radio Frequency Identification system on bins. MCGM and the Corporation of Chennai have deployed a global positioning system tracking system on garbage trucks to monitor their movements
- **Integrated SWM –** Corporation of Chennai and Corporation of the City of Panaji also have plans to setup facilities capable of storing, segregating and processing the solid waste.
- **Regional Cluster Approach –** Integrated SWM projects based on regional cluster approach have been promoted by the Government of Punjab (2014) wherein eight clusters comprising of 8 to 26 ULBs in each cluster covering all the ULBs in the State have been formed. The Department of Local Govt., Punjab has planned to develop these clusters on public-private Partnership basis and the SWM will be carried out in all the ULBs in the state as per the Punjab Model MSW Plan-2014, designed centrally at state level with local adaptations at the cluster level.

Responsibility for SWM on various government levels

While the onus of providing SWM services in urban areas lies with the ULBs, as specified in the MSW Rules 2000, Central and State Governments have a significant role to play in defining the frameworks within which service provision can be planned and executed by ULBs (see Table 4).

Table 4: Roles & responsibilities of key actors in SWM sector in India at various levels

Central Government	State Government	Local Government
Prepares rules and manuals that guide states in drafting their policies; provides financial support through the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), and grants under the Finance Commissions, etc.	Ensures implementation of rules and guidelines in the state; responsible for setting up authorities such as urban development departments, which are responsible for implementation of MSW management systems.	Implements the state guidelines for MSW management system; collection, transportation, street sweeping, processing and disposal of waste; makes land available for setting up of disposal facilities; and supervises work.
• MoUD ▪ formulates broad policies for sanitation sector including SWM ▪ prepares guidelines/ benchmarks for SWM services ▪ supports SWM projects under JNNURM/ UIDSSMT schemes ▪ facilitative role for ULBs' capacity building. • CPHEEO, technical wing of MoUD ▪ formulates broad policies for sanitation sector including SWM ▪ assists in technical matters on SWM ▪ prepares guidelines like technical manual on SWM • MoEFCC directly involved by way of deployment of municipal solid waste management Rules under the Environment Protection Act, 1986 • CPCB ▪ plays a monitoring role by convening meetings of various SPCBs ▪ seeks information in respect of initiatives taken up by ULBs ▪ reviews the information furnished by various SPCBs. • MoA and the MNRE ▪ play an active role in promoting and financially supporting composting of municipal solid waste and waste-to-energy projects.	• Department of Urban Development ▪ Secretary-in-charge: Overall responsibility for the enforcement of MSW Rules, 2000 • State Level Nodal Agency (SLNA) ▪ Project Monitoring Units (PMUs) • State Pollution Control Board (SPCB) ▪ plays a monitoring role & ▪ issues an authorisation to ULBs/ operators stipulating compliance standards • State Environment Impact Assessment Authority (SEIAA) ▪ Gives environmental clearances for setting up processing and disposal facilities	• At the sub-state level, the District Magistrate or the Deputy Commissioner of the concerned district has the overall responsibility for the enforcement of the provisions of the MSW Rules, 2000 within the territorial limits of their jurisdiction. • At the city/ULB level (74th Amendment Act, 1992), every municipal authority within the territorial area of the municipality is responsible for implementation of the provisions of these rules, and for any infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid waste. • Additionally, for monitoring and management of sanctioned projects of various sectors including SWM under JNNURM, Project Implementation Units (PIUs) at ULB level have been set up in many states.

Other important stakeholders

NGOs/civil society: NGOs and civil society or social workers often take lead in forming Ward Committees and community participation. These organisations absorb unemployed youth in the area for various jobs such as managing collection of garbage, helping the organisers in conducting road-shows, etc.

Communities and public: Communities and the public in general could potentially play a vital role by practicing sustainable consumption and implementing "3R" (reduce, recycle, reuse) concepts leading to reduction and segregation of waste at source. To facilitate this, the MoUD has created a **Community Participation Fund (CPF)** (JNNURM Sub-Mission for Urban Infrastructure and Governance, 2009) under which a community can conceive a project on MSW and submit it through the local municipality to the GoI.

Community Participation Fund (CPF)

Under the CPF, a community can conceive a project on MSW and submit it through the local municipality to the Union Government.

Funds to the tune of USD 16,000 (INR 0.95 million) can be granted with community contributing 5%, in case of slums and 10% in case of others.

However, 51% voters living in the locality there will have to sign a document indicating their interest and support to the project. ULBs could forward such proposals to GoI.

So far around 21 projects have been sanctioned under CPF, out of which only 2 are on MSWM for Madurai and Bangalore.

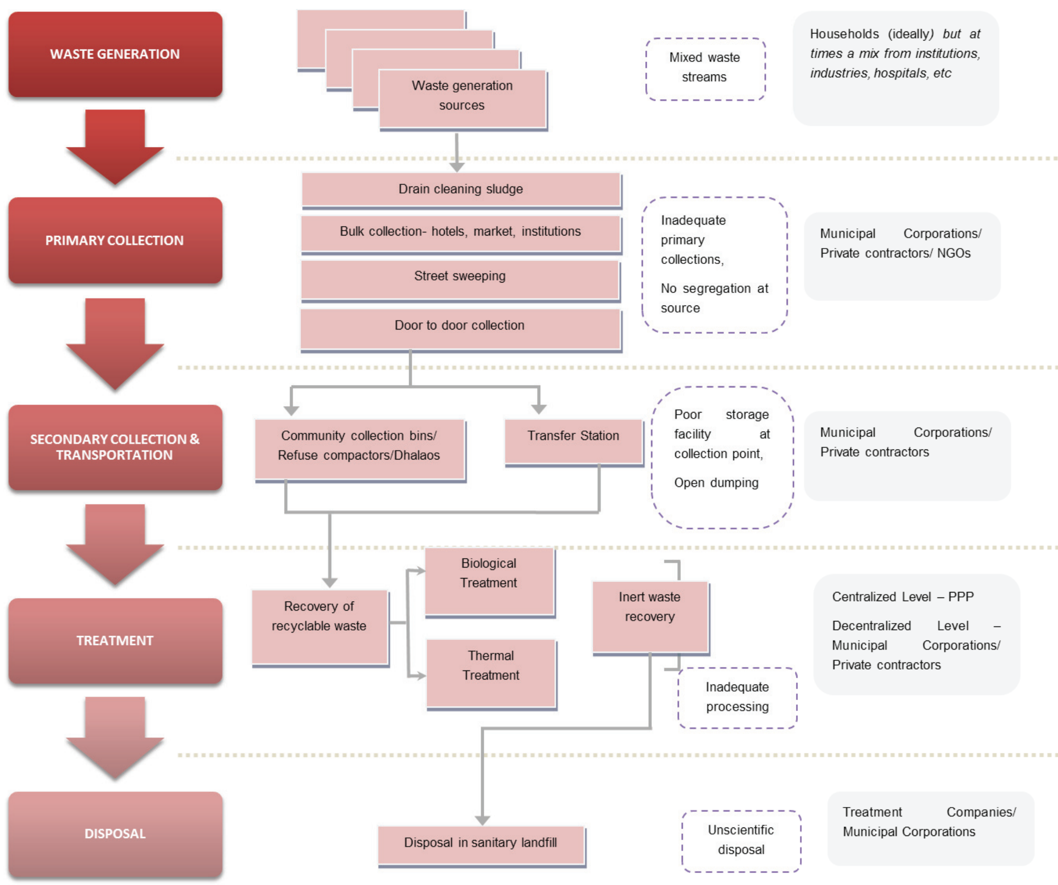
Waste Pickers: In the Indian context, rag pickers contribute a great deal in waste management as they scavenge the recyclable matter thereby saving the municipality the cost and time of collecting, segregating and transporting garbage to the dumps.

As stated before, SWM falls within the purview of the state government. The activities are entrusted to ULBs through state legislations. In the majority of the Indian cities, the MSW collection, segregation, transportation, processing and disposal is carried out by the respective municipal corporations and the state governments enforce regulatory policies. In some cities like Mumbai, Chennai, Delhi, Bangalore, Hyderabad, Ahmadabad etc., waste disposal is done by **PPPs**.

The **private sector** has been involved in door-to-door collection of solid waste, street sweeping in a limited way, secondary storage and transportation and for treatment and disposal of waste. Some private firms undertake collection, segregation & transportation, treatment (compost, bio-methanation; RDF), and final disposal. However, there are serious barriers to private sector participation in urban infrastructure as the financial status of ULBs except for a minority, is precarious. The urban sector is seen as a very high-risk sector and also because of institutional complexity due to multiplicity of agencies involved in service delivery. Further, there is lack of a regulatory or policy enabling framework for PPPs, barring few exceptions, and lack of financially sustainable and bankable projects considering the opportunities and risks involved. There is also a need to rationalise tariffs and user charges.

Figure 10 shows important steps and technical elements of the process of MSWM as well as associated key problems and actors.

Figure 10: Schematic Flow of SWM process and stakeholders



2.2 BASELINE GHG EMISSIONS FROM SWM

As per CPCB (2014), India generates 144.4 kilo tons of MSW per day and only 19% of it is treated. The remaining MSW is either not collected or dumped at SDWS, leading to significant amounts of methane emissions.

The present study is a first approach with the objective to establish the methodology for estimation of GHG emissions from MSW disposal at SWDS in cities with more than 20,000 inhabitants. The study is based on data and information available from secondary sources. It provides an estimate for historical, current and future emissions up to the year 2030.

The disposal of MSW produces significant amounts of methane (CH_4), and smaller amounts of nitrous oxide (N_2O). Hence in the context of the SWM NAMA feasibility study for India we focus on the estimation of CH_4 emission from SWDS, i.e. on the emissions generated in the dumpsites and sanitary landfills operated in the country. Emissions from biological treatment are also considered although they are far less significant in the present scenario. The methodology and approach provided in the revised IPCC 2006 Guidelines for national greenhouse gas inventories (IPCC, 2006) has been applied. The model to calculate emissions from disposal is based on the First Order Decay (FOD) method.

Furthermore, the study scope encompasses the MSW generated by the country´s urban population in cities of equal or more than 20,000 inhabitants where waste collection exists. In order to differentiate the sources of emissions with a spatial resolution and to facilitate the subsequent analysis, five city groups have been defined based on their population and their type of waste management. It is assumed that the dispersed waste disposal predominating in rural areas and very small cities does not generate significant methane emissions because no or little solid waste is piled up in the disposal sites in a way that forms anaerobic environments enabling methane generation.

The GHG inventory shows the historical emissions for the years from the year 1961 on, the current emissions and the projected future emissions to 2030 in a preliminary business-as-usual scenario that assumes maintaining the current technology mix. The study thus covers a historical 50 year data span as recommended by IPCC (2006) and the potential NAMA implementation period of the coming 15 years from 2016 on.

For the future development of a SWM NAMA and its underlying waste management and emission projections, it is recommended to estimate emissions using more country specific key parameters and improved quality of country specific activity data in comparison to the present study. The **future study** should differentiate the emission estimations to a higher degree in terms of city groups, country regions and/or climate zones etc. and it could be extended to cover smaller cities and rural areas of the country. This requires further differentiation of data based on alterations in MSW characteristics and MSW activity data over the years and anticipated future changes, as well as according to city groups. It should address the limitations identified in this study and include certain field studies in areas with currently weak data base. The future study should investigate the potential relevance of waste incineration and open burning at country level. It should also establish an agreed upon methodology and policy approach for the BAU or baseline scenario for the sector for emission forecast.

In the **present study**, a detailed step by step approach as outlined below has been applied for the estimation of GHG emission from municipal solid waste. This also includes the respective justification behind any assumption and indication of the limitations of the present work.

Step by step approach for estimation of GHG emissions from MSW disposal:

Step 1: Identification of city groups

Step 2: Selection of method for estimation of GHG emission from SWDS

Step 3: Determine choice of method

Step 4: Identification of data required for estimation of GHG emissions from waste disposal on SWDS and defining parameters

Step 5: Determination of CH_4 emission from SWDS

Step 6: Emissions from biological treatment of waste

Step A: Estimation of waste quantity which is treated biologically

Step B: Estimation of CH_4 and N_2O emissions from biological treatment of solid waste using equations

Step C: Subtraction of the amount of recovered gas from the amount of CH_4 generated to estimate net annual CH_4 emissions

Step 7: Presentation of results

Step 8: Comparison with data from the 2nd National Communication to the UNFCCC (MoEF 2011)

2.2.1 Step 1: Identification of city groups

India's population has been segregated into urban and rural population. It is estimated that dispersed waste disposal occurring in rural areas does not generate significant methane emissions as the decay is mainly aerobic in nature. Hence rural areas are not considered in the present study. Further, the GHG emissions from solid waste disposal varies with the waste characteristics and waste management practice of a given city and as mentioned in section 2.1, these largely depend on the life style and social status of the populations in urban cities (Sharholy et al., 2007). Hence the Indian cities can be grouped as per waste characteristics and waste management practice as well as life style and social status of population groups which has a correlation with the size of a city. Based on that assumption, GHG emissions can be estimated for each city group. The definition of the city groups for the purpose of this study aimed at generally utilising the city categories applied by Indian authorities, while differentiating them to a higher degree where necessary.

The Census of India (Ministry of Home Affairs, 2011a): has categorised following city groups based on population:

Class I: Above 100,000

Class II: Population between 50,000 to 100,000

Class III: Population between 20,000 to 50,000

Class IV: Population between 10,000 to 20,000

Class V: Population between 5,000 to 10,000

Class VI: Population below 5000

Cities with less than 20,000 populations (Class IV, V and VI) do not generate significant methane emissions as the decay is mainly aerobic in nature. Hence cities with less than 20,000 populations are not considered in the present study.

Class II and Class III generate less than 40 tons of waste per day (considering around 400 grams/capita/day of waste generation) with low collection and treatment of waste before disposal to dump sides. Hence these cities are similar cities in terms of waste generation and waste disposal practices and these cities can be grouped together in one city group.

Class I city group (above 100,000 populations) consists of bigger cities with varying life style and waste management practice and hence this should be further sub-grouped. The city categorization provided in MoUD and CPHEEO (2014) shown below can be used for sub-grouping of class I cities:

1. Up to 50,000
2. Population between 50,000 to 100,000
3. Population between 100,000 to 500,000
4. Population between 500,000 to 1 million
5. Above 1 million

Hence Class I city group can be sub-grouped into following city groups:

1. Population between 100,000 to 500,000
2. Population between 500,000 to 1 million
3. Above 1 million

Cities above 5 million inhabitants have witnessed rapid increase in population in past decade and hence these cities are classified into a separate city group.

The Planning Commission (2014) has identified the following three city classes for tentative capital cost estimation for processing of various fractions of MSW:

1. Below 100,000
2. Population between 100,000 to 1 million

3. Above 1 million

Based on the above analysis, the urban population has been categorised into the following five city groups, considering that waste generation and waste management practices show a certain correlation with city size:

1. Population from 20,000 to 100,000
2. Population from 100,000 to 500,000
3. Population from 500,000 to 1 million
4. Population from 1 to 5 million
5. Population above 5 million

Input parameters required for estimation of GHG emissions have been estimated individually for each city group. The approach for estimation of input parameters for each city group has been provided in **step 4**.

2.2.2 Step 2: Selection of method for GHG emission from SWDS

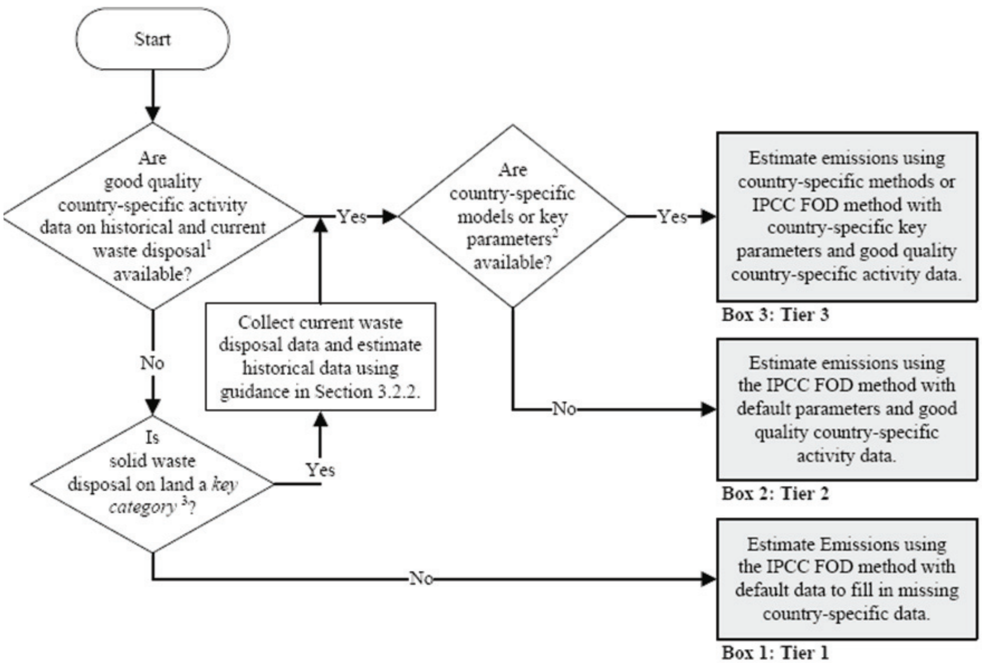
As per IPCC (2006), it is good practice for all countries to use the FOD method or a validated country-specific method, in order to account for time dependence of the emissions.

Since India does not have any country specific GHG emission method, IPCC FOD method has been used for estimation of GHG emission from waste disposal to SWDS.

2.2.3 Step 3: Determine choice of method

IPCC (2006) provides three levels (tiers) to estimate the CH_4 emissions from SWDS. The appropriate approach would be decided based on the decision tree diagram shown in Figure 11.

Figure 11: Decision tree for CH_4 emissions from SWDS (IPCC, 2006)



Notes on the figure:

1. Good quality country-specific activity data means country-specific data on waste disposed in SWDS for 10 years or more.
2. Key parameters mean DOC/L_0, DOCf and half-life time.

Justification for choice of method as per steps provided by IPCC (2006):

Question: Are good quality country-specific activity data on historical and current waste disposal available? Here the good quality data refers to country specific data on waste disposal in SWDS for 10 years or more.

Response: No. India does not have waste disposal data in SWDS for all urban areas for 10 years or more.

Question: Is solid waste disposal on land a key category?

Response: Yes.

Question: [If above "yes"] Collect current waste disposal data and estimate historical data using guidance in section 3.2.2 of IPCC (2006).

Response: Population data has been used as a proxy for estimating waste disposal data.

Question: Are country-specific models or key parameters available? Here key parameters are DOC/L_0, DOC_f and half-life.

Response: In the present analysis, country specific models (DOC/L_0, DOCf and half-life) or key parameters are not available.

Outcome: Utilisation of Tier 2 method, estimation of emissions using the IPCC FOD method with default parameters and good quality country specific activity data.

The IPCC Waste Model (FOD spreadsheet model) has been used for estimation of CH_4 emission from SWDS. The spreadsheet keeps a running total of the amount of decomposable DOC in the disposal site, taking into account the quantity of MSW deposited each year and the amount remaining from previous years. This is used to determine the amount of organic matter decomposing to CH_4 and CO_2 each year. This has been executed for each of the city groups, based on their specific parameters, and the GHG emissions have been finally aggregated.

The IPCC Waste Model provides two options for the estimation of the emissions from MSW. The first option is a multi-phase model based on **waste composition data**. The amounts of each type of degradable waste material (food, garden and park waste, paper and cardboard, wood, textiles, etc.) in MSW are entered separately. The second option is single-phase model based on **bulk waste** (MSW).

In the present analysis, the first option i.e. the **waste composition data option has been used for estimation of GHG emissions.** For this purpose waste composition data have been derived specifically for each city group, based on waste characterization studies available within each group.

Step 4: Identification of data required for estimation of GHG emissions from waste disposal on SWDS and defining parameters

In line with IPCC 2006 recommendation, wherever possible, country specific data has been used for establishing the parameters below. In the absence of country specific data, the IPCC default value for the given parameters has been used.

a. Population

IPCC (2006) recommends using solid waste disposal (amount and composition) data from the past 50 years. It recommends estimating these data using surrogates (extrapolation with population, economic or other drivers) for countries that do not have historical statistical data, or equivalent data on solid waste disposal that go back for the whole period of 50 years or more. The missing historical data can be estimated to be proportional to urban population.

Since India does not have good quality country specific activity data on waste disposed in SWDS for past 10 years or more, a surrogate like population data for the past 50 years has been used for estimation of MSW disposal (amount and quantity) data. The year wise population data for each city group has been derived for the period from 1961 to 2030. This includes backward and future population projection considering 2011 as base year.

The Census of India has been conducted every 10 years and population data is provided for the following city groups:

Class I: Above 100,000

Class II: Population between 50,000 to 100,000

Class III: Population between 20,000 to 50,000

City groups identified in step 1 are not in-line with city classes identified by the census. Hence it was necessary to estimate population numbers for each city group from the census data. The Ministry of Home Affairs (2011b) provides city wise population data for class I cities (population above 100,000). This has been the basis for estimation of population in 2011 for following city groups:

Population between 100,000 to 500,000

Population between 500,000 to 1 million

Population between 1 to 5 million

Population above 5 million

The population of the remaining city group (population between 20,000 to 100,000) is the sum of class II & class III cities. We were able to retrieve the population data for class II and class III cities from the Census of India (2001) for all decades (1961 to 2001) except 2011. Hence the population for 2011 has been estimated based on past decadal growth rate of 20% for class II and class III cities. The table below provides information on data obtained from the census.

Table 5: Population for identified 4 city groups 2011 (in million)

City groups	2011
100,000 to 500,000	85.63
500,000 to 1 million	30.62
1-5 million	74.4
Above 5 million	58.4

Table 6: Population for city group with population between 20,000 to 100,000 for past decades (in million)

City groups	2001	1991	1981	1971	1961
20,000 to 100,000	76.6	64.0	48.8	34.6	25.3

City wise population data for class I cities for previous decades could not be found from the Census of India (2001). Therefore, population data for identified city groups has been projected based on available growth rates from 118 sample cities. Please refer to Appendix 2 for list of 118 sample cities and reference for their decadal population.

Backward projection of population

Historical population data for each sample city has been derived from individual town directories and census data (Appendix 2). By this approach, the average growth rate of sample cities belonging to each city group has been used to establish the growth rate of that city group.

Due care has been taken not to select cities with unreasonable population growth rates, i.e. negative or very high growth rate. The growth rates for selected city groups have been summarised in Table 7.

Table 7: Decadal population growth rate for identified city groups

City groups	2001	1991	1981	1971	1961	Sample size
20,000 to 100,000	Not available	20%	31%	41%	37%	-
100,000 to 500,000	25%	43%	47%	47%	36%	85
500,000 to 1 million	43%	64%	88%	45%	46%	17
1-5 million	69%	92%	93%	52%	52%	15
Above 5 million	48%	99%	38%	44%	40%	1

This growth rate has been used for estimation of past decadal population for each city group. The aggregate of decadal population for each city group has been compared with census data and the result has been summarized below.

Table 8: Decadal population (in million) for identified city groups

City groups	2001	1991	1981	1971	1961
20,000 to 100,000	76.6	64.0	48.8	34.6	25.3
100,000 to 500,000	68.53	47.96	32.6	22.12	16.32
500,000 to 1 million	21.39	13.07	6.96	4.80	3.29
1-5 million	44.0	22.9	11.8	7.8	5.1
Above 5 million	39.5	19.8	14.4	10.0	7.1
Population as per census (Class I, II and III cities)	254.8	186.3	131.0	87.4	60.0
Deviation	-1.9%	-10%	-12.6%	-9.3%	-4.8%

The comparison shows that the maximum deviation is 12.6% in 1981. This error should not have much impact given the assumption that much of waste decomposes in the beginning of disposal. Hence the result of backward extrapolation is appropriate. Year-wise population data from 1960 to 2011 for each year has been generated by using decadal population and linear interpolation method.

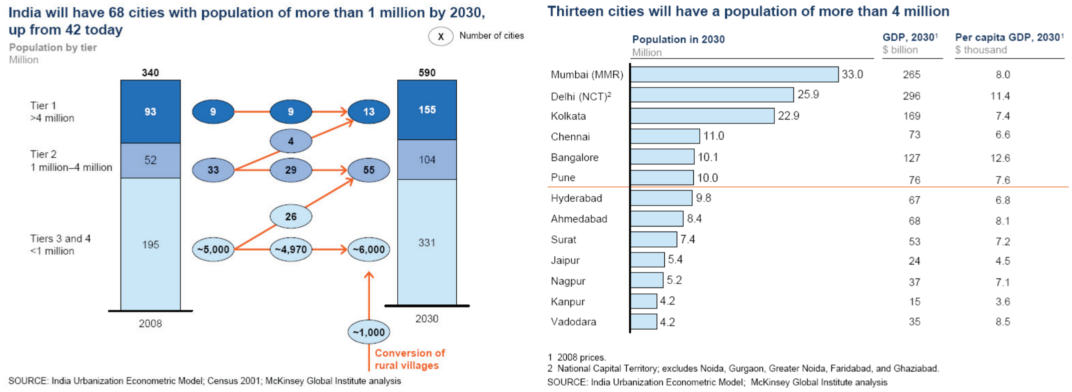
Note on polulation estimation

It is important to highlight that the present approach for population estimation gives slightly lower population compared to census data and hence all the assumption made for population projection will have a conservative impact on GHG. emission.

Future population projection

Population data from 2012 to 2030 has been estimated by using population projection provided by McKinsey Global Institute (2010). As per this projection for 2030, India's urban population is expected to be 590 million and will comprise 11 cities with more than 5 million inhabitants and 57 cities with more than 1 million inhabitants but less than 5 million inhabitants (see Figure 12).

Figure 12: Population projection for 2030 (McKinsey Global Institute, 2010)



The information provided in the above figure has been used for estimation of 2030 population for each city group.

Table 9: Population forecast for each of the identified city groups

City groups	2030	Remarks
20,000 to 100,000	129.2 million	Kundu (2006) finds that cities with more than 20,000 but less than 100,000 inhabitants constitute approximately 21.9% of total urban population in 2001. As per McKinsey Global Institute (2010), the urban population is 590 million in 2030. Hence the projected population for this city group will be approximately 129 million (21.9% of 590 million).
100,000 to 500,000	104 million	As per the information provided in the table below, the urban population sharing of cities with less than 20,000 habitants has shrunk to 10% of urban population in 2001. It has been assumed that the urban population sharing will remain the same in 2030. As per this assumption, the population for this city group (100,000 to 1 million) has been estimated by subtracting other city group's population from total urban population in 2030. This projected population has been used to estimate the annual population growth rate from 2012 to 2030 for city group with 100,000 to 1 million. The estimated annual population growth rate has been used for estimation of population for city group with 100,000 to 500,000 and 500,000 to 1 million.

Census Year	Share of urban population with less than 20,000 population
1901	47%
1911	46%
1921	44%
1931	40%
1941	34%
1951	30%
1961	20%
1971	16%
1981	14%
1991	11%
2001	9.4%

		Projected population for 100,000 to 1000,000 in 2030 = 590 – 112.4 – 148.2 – 129.2 -10%*590 = 141.2 million Annual population growth rate for city group with 100,000 to 1 million people from 2012 to 2030 (CAGR method) = (141.2/116.26)^(1/19)-1 = 1.028% Projected population for city group with 100,000 to 500,000 people = 85.63*(1+1.028%)^19 = 104 million
500,000 to 1 million	37.18 million	Projected population for city group with 500,000 to 1 million people = 30.62*(1+1.028%)^19 =37.18 million
1-5 million	112.4 million	Population projection as per McKinsey Global Institute (2010)
Above 5 million	148.2 million	

The urban population projection provided by McKinsey has been compared with the population projection provided by World Bank (2014) and Census of India (2006). It has been found that the population projection provided by McKinsey Global Institute (2010) is within conformity with the other projections. As it provides population projections for city groups with 1-5 million and above 5 million people, its population projection for 2030 has been used in the present study.

Table 10: Comparison of population projections provided by various sources for 2030 (million)

Year	World Bank	Census	McKinsey
2026	536.8	534.8	
2027	548.2		
2028	559.7		
2029	571.4		
2030	583.0		590.0

Year wise population from 2012 onward to 2030 has been generated by using linear interpolation method.

Limitations of population projection:

1. Historical data for city groups with more than 100,000 populations has been estimated based on decadal growth rate of sample cities belonging to these city groups. The sample size for city groups with more than 1 million population is small.
2. Sample size is not sufficient for selected city groups. Sample size should be decided based on population size of each city group, confidence level and acceptable error limit.
3. Year wise population has been estimated by using linear interpolation method and this does not cover the impact of rapid urbanization taken place in last few years.
4. Population projection for the three city groups with less than 1 million population is based on assumptions which need to be validated.
5. Many cities are likely to change their city group with an increase in population over time. However, such impact has not been considered in the present estimate.

b. Waste generation rate (gram per capita and day or gram/capita*day)

In the present approach, it has been assumed that the waste generation rate will vary between the identified city groups. Hence the waste generation rate for each city group has been estimated based on available waste generation rates from 128 sample cities. Given the absence of a central repository of projects related to MSWM, the information has been extracted from reports for 10 cities (Agra, Coimbatore, Kochi, Kolhapur, Mysore, Nasik, Rajkot, Simla, Surat and Tambaram) prepared by municipal corporations to get JNNURM funding, National Environmental Research Institute (NEERI) reports for 59 cities (NEERI, 2005) and other available city reports (quoted in Appendix 3).

In the present analysis, it has been assumed that cities with lower population will have lower collection efficiency compared to cities with larger population, summing up to an average collection efficiency of 65%. The given assumption is in conformity with information provided by the Planning Commission (2014). Collection efficiency ranges from 70% to 90% in major metro cities while in smaller cities it is below 50%. The estimated waste generation and collection rates have been summarised in the table below.

Table 11: Waste generation rate and generation to collection ratio for identified city groups

City groups	Gram/capita and day	Sample size	Generation/ collection
20,000 to 100,000	349	15	50%
100,000 to 500,000	375	24	60%
500,000 to 1 million	411	28	65%
1-5 million	423	49	70%
Above 5 million	485	12	80%
Comparison with default IPCC value provided for India in 1996 as per IPCC (2006, Ch2, table 2A.1)	329		
Comparison with waste generation rate provided by Planning Commission (2014)	200 to 600		

The average waste generation rate for the five city groups is 409 gram/capita and day which is comparable with the waste generation rate provided by IPCC for India in 1996, given 1.5% annual increase in generation rate over past 18 years (from 1996 to 2014). The average waste generation rate is also comparable with the average waste generation rate, 450 gram per capita and day provided by the Planning Commission (2014).

Note on collection efficiency

The actual collection efficiency might be lower given the fact that much of the waste is either dumped in the open, eaten by animals, burnt in the open or recyclables are picked by waste pickers. Hence the present estimate might lead to a higher share of organic material in disposal sites and might over-estimate the methane generation.

Limitations of waste generation rate estimation

1) It has been assumed that the waste generation rate varies with the population of identified city groups, however, the estimated generation rates do not completely correlate with city size. The hypothesis of correlation cannot be confirmed by using regression analysis (value of R2 is very low). This may be due to small sample size. Sample size in future studies should be decided based on population size of each city group, confidence level and acceptable error limit.
2) Waste management policies to reduce waste generation and to promote alternatives to solid waste disposal have not been taken into account in the analyses of future waste generation.
3) Waste generation rates also dependson state GDP, personal disposable income, literacy rates etc. If a correlation holds true, these factors can make the data estimation more reliable. Hence information apart from population can also be used while forming separate city groups.

The waste generation rate has been projected from 1961 to 2030 by considering 2011 as base year and a 1.5% annual growth rate. A growth of 1,5% of per capita waste generation is a common assumption for rapidly developing countries with changing consumption patterns like India. This assumption is in conformity with information provided by the Planning Commission (2014) on the annual increase in the waste generation rate. It estimates the annual increase in overall quantity of solid waste at ~5% which is understood to be a product of the 3 to 3.5% of urban population growth multiplied with per capita waste generation and insofar is not inconsistent to the present assumption.

c. Waste composition

As mentioned in Step 3, waste composition data has been used for estimation of GHG emissions instead of bulk waste data. This option requires data on separate types of degradable waste materials (food, garden and park waste, paper and cardboard, wood, textiles etc). NEERI (2005), however, only provides waste composition data for 59 cities in terms of compostable and recyclable. Hence NEERI report cannot provide detailed waste composition data. The reports by JNNURM (2009) have also been considered for waste composition data. However, these reports also do not provide detailed waste composition in terms of food, garden and park waste, paper and cardboard, wood, textiles etc. Waste projects in the CDM pipeline do provide waste composition data (in terms of food, paper, textile etc.) in line with IPCC requirements. This data is part of detailed project reports (DPR) and validated by an independent third party. The DPRs are also the basis for getting an approval for electricity tariffs and tipping fees. Hence information provided from CDM projects is of extremely high quality and is used by us. Apart from CDM projects, individual city reports are referred to for waste composition data for the respective city groups.

In the present study, waste composition for each city group has been estimated from data available from 27 sample cities. Data for 24 cities has been derived from waste projects in the CDM pipeline (UNEP DTU, 2015a) and the remaining data for cities like Hyderabad (Sastry, no date), Mumbai (ibid.) and Kolkata (SCS Engineers, 2010) have been referred from individual city reports. Data from the CDM pipeline has been used for the estimation of carbon credits from solid waste disposal to landfill sites. Hence it was assumed that the composition of waste refers to waste as disposed of at the disposal sites.

Table 12: Detailed waste composition for identified city groups

City groups	Food	Garden	Paper	Wood	Textiles	Nappies	Plastics, other inert	Sample size
20,000 to 100,000	63.6%	13.7%	5.1%	3.6%	2.9%	0.0%	11.0%	5
100,000 to 500,000	39.0%	31.5%	5.9%	4.1%	2.9%	0.0%	16.6%	5
500,000 to 1 million	43.0%	21.8%	5.5%	3.1%	3.1%	0.0%	23.4%	4
1-5 million	54.4%	18.9%	6.9%	3.3%	2.8%	0.0%	13.6%	4
Above 5 million	44.8%	18.3%	6.6%	4.2%	3.8%	0.0%	22.3%	9

As Ecoparadigm found for Tirupati city, there is a roughly 5% reduction in biodegradable component in the entire waste stream from the source of waste generation to the disposal site (Ecoparadigm, 2013). The study highlights the decrease in the share of biodegradable waste from 70% to 66% from the site of waste generation to the disposal site. This is mainly due to loss of moisture during transportation and a part of biodegradable waste eaten by stray animals. Since this loss is not significant, the estimated waste composition data from individual city reports holds good for disposal sites.

Limitations of waste composition estimation

1) It has been assumed that waste composition varies with population of identified city groups. However this hypothesis cannot be confirmed by using regression analysis (value of R2 is very low). This may be due to small sample size.
2) The hypothesis is that waste composition varies with population size. However in practice, waste composition also depends largely on the lifestyle and alimentation of people which generally varies with region. For example, the biodegradable content is relatively high in Southern part of India. But this impact has not been considered while estimating detailed waste composition.
3) It is known that most studies refer to "composition at generation point (households)", and it is likely that in India recyclables over-proportionally but also organic matter do not reach the disposal site. Hence the utilised composition data should be confirmed with actual composition data at disposal. site.

d. Degradable organic carbon (DOC)

In the absence of country specific DOC (wet basis) data, the default DOC values for waste components provided by IPCC (2006) has been utilised.

Limitations of DOC estimation

1) DOC may see wide variation among Indian cities. Hence actual study results, when available, should be used for DOC data.

Fraction of Degradable Organic Carbon which decomposes (DOC_f): Fraction of degradable organic carbon which decomposes (DOC_f) is an estimate of the fraction of carbon that is ultimately degraded and released from SWDS, and reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, under anaerobic conditions in the SWDS. The recommended IPCC default value for DOC_f is 0.5 and the same value has been used in the present analysis.

Limitations of DOC_f estimation

1) Default IPCC value is applicable under the assumption that the SWDS environment is anaerobic and the DOC values include lignin. However this assumption is not true as many SWDS sites are low height and aerobic in nature.
2) DOC_f value is dependent on many factors like temperature, moisture, pH, composition of waste, etc. which vary across India. The actual variation in these parameters may have impact on actual DOC_f value.

e. Methane correction factor (MCF)

IPCC (2006, Table 3.1) provides MCF default values for the following categories of SWDS:

1. Managed-anaerobic
2. Managed-semi-aerobic
3. Unmanaged – deep (>5m waste) and/or high water table
4. Unmanaged – Shallow (<5m waste)
5. Uncategorized SWDS

As per CPCB (2014), there are 69 landfill sites constructed and operational in the country and initiatives have been taken for construction of 164 new landfill sites. The landfill construction has been completed mostly in the states of Andhra Pradesh (2), Chandigarh (1), Delhi (3), Goa (7), Gujarat (12), Haryana (4), Karnataka (12), Madhya Pradesh (5), Maharashtra (6), Punjab (1), Manipur (1), Rajasthan (1), Tripura (1) and West Bengal (13). But the report does not provide the classification of landfill sites in terms of managed, unmanaged, shallow or deep. However, there are individual city reports which provide classification of landfill sites for cities with more than 5 million people (see Table 15). These reports have been used for the estimation of MCF for cities with more than 5 million inhabitants.

For other city groups, the following approach has been adapted for the classification of landfill sites. In this approach the time required to fill a typical landfill site (5 metre height and 45 hectare land area) has been estimated based on following information.[5]

Table 13: Parameters required for estimation of time taken to reach 5 meter height

Parameter	Value	Unit	References
Density of MSW	300-400	kg/m^3	Katiyar (2013)
Estimation for population below 500,000			
Typical landfill area	20	Hectare	Assumed
Typical landfill area	200,000	m^2	Calculated
Critical height	5	m	As per IPCC (2006)
Volume of landfill at 5m height	1 million	m^3	Calculated
Required quantity of waste	350,000	Ton	Calculated
Estimation for population above 500,000			
Typical landfill area	50	Hectare	Assumed
Typical landfill area	500,000	m^2	Calculated
Critical height	5	m	As per IPCC (2006)
Volume of landfill at 5m height	2.5 million	m^3	Calculated
Required quantity of waste	875,000	Ton	Calculated

The time taken to fill a typical landfill site for each city group has been provided below.

Table 14: Estimation of time taken to reach 5 meter height for a landfill site

City group	Number of cities[6]	kg waste / cap / day	Million tons per year[7]	tons/year/ city[8]	Time taken (years)
20,000 to 100,000	1,893	0.349	5.8	3,084	113
100,000 to 500,000	454	0.375	7.0	15,510	23
500,000 to 1 million	45	0.411	3.0	66,276	13
1-5 million	42	0.423	8.0	191,445	5
Above 5 million	6	0.485	8.2	459,520	2

It is evident that the city groups with 20,000 to 100,000 populations and with 100,000 to 500,000 people will take more than 15 years time (significantly higher compared to the implementation timeframe of the NAMA) to achieve 5m landfill height and hence these landfill sites will be unmanaged and shallow (<5m) landfill sites.

Time taken to fill landfill sites for city group with 500,000 to 1 million people is slightly less than 15 years (NAMA lifetime), hence this city group will fall under the 'unmanaged – shallow' category and the 'unmanaged – deep' category. It has been assumed that 75% of the waste generated from 500,000 to 1 million city groups are dumped into shallow landfill sites (<5m height) and the remaining waste is dumped into deep landfill sites (> 5m height).

5 In this analysis, it has been assumed that smaller cities (<500k) population will have less landfill area compared to bigger cities.
6 Number of cities as per 2011 census
7 Waste disposal quantity for each city group in 2011
8 Assuming each city, below 5 m population has a landfill area and cities above 5m population have 3 landfill sites.

For the next city group with 1-5 million people, the time taken to fill landfill sites is less considering a typical landfill area of 50 hectare. Hence this city group will fall under the 'unmanaged – shallow' category and the 'unmanaged – deep' category. Since 33 out of 42 cities from this group fall below 2 million people, it has been assumed that 75% will have shallow depth and the remaining 25% will have deep depth.

Classification for the largest city group (above 5 million people) landfill sites has been estimated from individual city reports. As per 2011 census, there are 6 cities with more than 5 million people (Ministry of Home Affairs (2011b). Table 15 provides a status of disposal sites in these cities.

Primary evidence for classification of landfill sites

Classification of landfill sites for each city group has been confirmed with a National waste management expert. K.P. Pravinjith has personally visited various landfill sites and the actual scenario is quite different from the one quoted in CPCB (2014). The CPCB (2014) document suggests that cities like Hyderabad and Ahmadabad have sanitary landfill sites while a visit to these cities reveals that currently rather the criteria for "unmanaged deep SWDS" are fulfilled, although both have been constructed as Sanitary Landfill with liners and leachate collection system as per MSW Rules 2000.

Table 15: Waste disposal practices in cities with more than 5 million inhabitants

City	Location	Height	Status	Area (Hectares)	Reference
Ahmadabad	Pirana	22m	Unmanaged deep	84	Shaikh et al. (2014)
Hyderabad	Auto Nagar	15m	Unmanaged deep	18	Hyderabad (2007)
Bangalore	Mavallipura	20m	Unmanaged deep	40	Subanna et al. (2010)
Kolkata	Dhapa	22m	Unmanaged deep	34.2	WBPCB (2014)
	Garden Reach	17m	Unmanaged deep	8	Hazra (2009)
Delhi	Ghazipur	25.5 to 30.5 m	Unmanaged deep	28	Sharma (2013)
	Bhalaswa	18m	Unmanaged deep	16	
	Okhla	27 to 40m	Unmanaged deep	13	
	Narela- Bawana	40m	Unmanaged deep	40	Ranjan et al. (2014)
Greater Mumbai	Deonar	22m	Unmanaged deep	132	SCS Engineers (2007)
	Mulund	13m	Unmanaged deep	25	MPCB (2014)
	Gorai	32m	Unmanaged deep	20	Datta (2010)
	Kanjur	More than 5 m	Unmanaged deep	131	MPCB (2014)
Average area				45.3	Calculated

Based on the above mentioned information, the overall percentage distribution of waste disposal for each city group has been summarised in the table below:

Table 16: MCF value for identified city groups

City groups	Unmanaged – Shallow (<5m waste) - 0.4	Unmanaged – deep (>5m waste) and/or high water table - 0.8	Managed-anaerobic - 1.0	Managed-semi-aerobic - 0.5	Weighted average of MCF
20,000 to 100,000	100%	0%	0%	0%	0.40
100,000 to 500,000	100%	0%	0%	0%	0.40
500,000 to 1 million	75%	25%	0%	0%	0.50
1-5 million	25%	75%	0%	0%	0.70
Above 5 million	0%	100%	0%	0%	0.80

Limitations of MCF estimation

1) Data required for estimation of MCF values for city groups other than city group with above 5 million people is not available; therefore the MCF is not validated from actual data. For the future, it is recommended to estimate MCF values from limited sample city data within each city group based on actual site visits.
2) Waste disposal practices within a city or city group changes with time. However, the impact of the same has not been considered in this analysis.
3) A number of cities will change the city group in future and this will impact their waste disposal practices. This, however, has not been considered in the present analysis.

f. Fraction of CH_4 in generated landfill gas (F)

Most waste in SWDS generates a gas with approximately 50 percent CH_4. Measured data for Indian cities is not available. Hence a default value of 0.5 has been considered in line with IPCC recommendation.

Limitations

Methane fraction can be more than 50% in case there is significant amount of fat or oil present in the solid waste.

g. Oxidation factor (OX)

As per IPCC (2006), the default value for oxidation factor is 0. The use of the oxidation value of 0.1 is justified for covered, well-managed SWDS to estimate both diffusion through the cap and escape by cracks/fissures.

It has been assumed that only 10% of SWDS are covered and well managed in India. Hence 0.01 has been considered as Oxidation factor.

h. Methane generation rate (k)

The half-life is affected by a wide variety of factors related to the composition of waste, climatic conditions at the site where the SWDS is located, characteristics of the SWDS, waste disposal practices and others.

The default methane generation rate (k) value provided in IPCC (2006, table 3.4) for given climate zone and type of waste has been used for calculation.

For the purpose of this study, average climatic condition of India have been considered tropical, moist and wet with more than 20°C mean annual temperature and more than 1000 mm of annual rainfall (Ministry of Earth Sciences, 2015).

i. Methane recovery (R)

There are very few landfill gas recovery plants in India and the amount of gas recovery is negligible compared to total methane emission from SWDS. Hence the methane recovery parameter has been considered 0.

j. Delay time

Methane emission does not begin immediately after deposition of the waste. It may take several months to decay and emit CH_4. IPCC (2006) provides a default value of six months for this time delay and the same value has been considered in the present analysis.

2.2.4 Step 5: Determination of CH_4 emission from SWDS

Methane emissions from waste disposal to SWDS sites have been estimated per city group as per IPCC (2006, equations 3.1 to 3.6) for each city group. CH_4 emissions for the city groups have then been aggregated for methane emissions from urban population at country level, and converted into CO_2 eq.

2.2.5 Step 6: Emissions from biological treatment of waste

As per CPCB (2014), there were 645 compost/vermin-compost plants reported till the year 2012-13 and 71 waste to energy related projects (RDF/pellet-18, Biogas Plants-41 and Power Plant-13) reported till the years 2013-14. However, the CPCB report does not provide the current operating status of all these reported plants and thus it is difficult to identify the quantity of waste processed by each technology.

As per Planning Commission (2014, Table 2), there are 279 composting plants, 138 vermicomposting plants, 172 Bio-methanation plants, 29 RDF (pelletisation) plants and 8 WTE plants for processing of waste. Table 10 of the same report shows that the 5 major WTE projects have been closed and Table 5 of the report suggest that currently three WTE plants (M/s SELCO International Ltd. Waste Management Plant, Hyderabad; Rochem waste to energy plant, Pune; and Okhla waste to energy plant, Delhi) are operating. The treatment capacity of SELCO, Rochem and Okhla plant is 150, 250 and 1100 tons per day, respectively. The total amount of waste treated by WTE technology is 1500 tons per day and represents 5.5% of the total amount of waste treated in India (CPCB, 2014). The remaining waste quantity, i.e. 94.5%, is either treated by composting, vermicomposting, bio-methanation or RDF (pelletisation).

Since the number of composting, vermicomposting and biomethanation plants is larger than that of RDF (pelletisation) plants, it has been assumed that the composting, vermicomposting and biomethanation (biological treatment) are the major technologies for treatment of 27.1 kilo tons of waste per day in 2014. The biological treatment process releases a certain amount of CH_4 and N_2O into the atmosphere. Hence in this section, emissions from biological treatment of waste have been estimated in line with IPCC (2006, Chapter 4). The estimation of CH_4 and N_2O emissions from biological treatment of solid waste involves the following steps:

Step A: Estimation of waste quantity which is treated biologically

As per discussion with Ecoparadigm and Karnataka Compost Development Corporation (KCDC), the oldest plant was commissioned in 1974 with a processing capacity of 150 tons per day. Hence it has been assumed that waste treatment at a large scale has been started after 1974. In absence of more specific information, it has been assumed that all composting plants belong to cities with more than 5 million people. The amount of organic waste treated has been estimated based on waste composition applicable for this city group. A linear interpolation has been used to estimate the annual quantity of waste generation from 1974 to 2014. The following approaches for business as usual (BAU) scenarios could be considered for estimating future waste treatment quantities.

1. **No capacity addition:** The same amount of waste as in 2013-14 will be treated in the future.

2. **Capacity addition with the same technology mix:** The shares of waste treatment technologies will remain unchanged. This scenario could also consider waste to energy plants that are at tendering stage or under construction and are likely to be operational in the near future.
3. **Enhanced action:** Considering policy targets of Government of India (GoI), e.g. MSW Rules' zero targets for waste disposal.

In the present analysis, scenario 1 is used, so the emission baseline is high compared to the other scenarios. Projects at tendering stage or under construction could be considered when a moderate BAU scenario is chosen within further phases of NAMA development. In the framework of this feasibility study, this was not possible due to time and resource constraints as it requires primary data collection from individual project documents.

Step B: Estimate the CH_4 and N_2O emissions from biological treatment of solid waste using equations

CH_4 and N_2O emissions have been estimated by using equation 4.1 and 4.2 of IPCC (2006). The table below provides the organic mass disposal and emissions from biological treatment in India. These emissions have also been compared with total sector emission and it has been found that the emissions from biological treatment are of low significance (less than 5%) in comparison with the emissions from SWDS.

Table 17: Organic mass disposal and emission from biological treatment in India

Year	Mass of organic waste treated (kilo tons)	CO_{2eq} emissions from biological treatment (kt)	Total sector emission, CO_{2eq} (kt)
1974	54.57	10	2,058
2010	4,000	772	15,095
2014	4,438	856	18,665
2030	4,438	856	41,097

Sector emission from biological treatment of waste is responsible for less than 8% of the total emission from waste disposal in any year. Hence the assumption regarding selection of composting technology for waste treatment is valid and it does not result in over-estimation of GHG emissions from waste disposal. In a future phase of NAMA implementation, with more detailed information on individual plants, this assumption can be adjusted.

Step C: Subtract the amount of recovered gas from the amount of CH_4 generated to estimate net annual CH_4 emissions

The amount of MSW disposal has been reduced by amount of waste biologically treated each year for city group with more than 5 million populations. CO_{2eq} emissions have been estimated from disposal of remaining waste to SWDS sites. Emissions from biological treatment of waste have been added to the estimated emission from solid waste disposal to SWDS sites.

Limitations

1) It has been assumed that waste has been treated biologically however in practice a part of waste is also treated by using other technology options like incineration. Emissions from incineration and open burning are not considered in the present study.
2) The throughput of the composting plants is likely to be lower than the plant capacity data, but there is no data on that gap available.
3) It has been assumed that all composting plants belong to city group with more than 5 million population only.

2.2.6 Step 7: Presentation of results

GHG emission (CO_2 eq) from solid waste disposal to SWDS sites[9] have been summarised in Figure 13 below using 25 as global warmin potential (GWP) for CH_4. Please refer to Appendix 2 for the annual values.

Figure 13: Emissions from MSW disposal and from biological treatment of waste

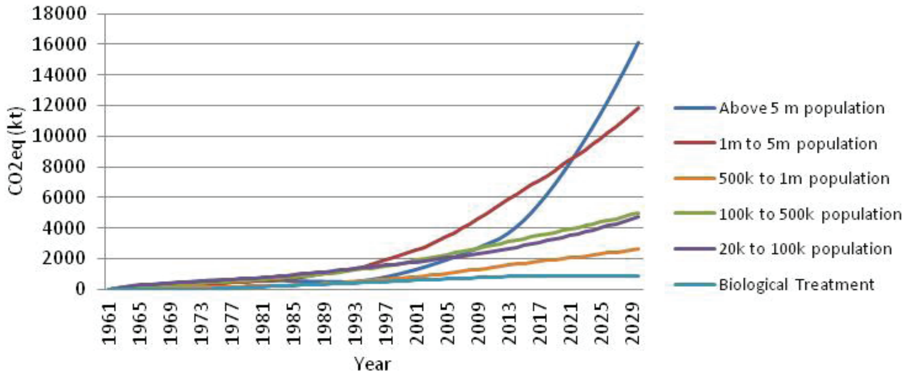
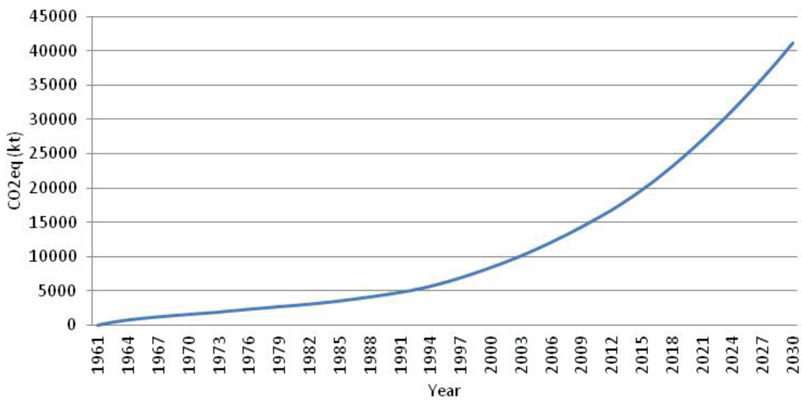


Figure 14: Total sector emissions from waste disposal to SWDS



The results show that there is sharp increase in emissions for city groups with more than 5 million inhabitants and the city group with a population between 1 million to 5 million inhabitants. This is mainly due to the population growth triggered by the high rate of urbanisation in these cities, in combination with the projected growth of the waste generation rate per capita and the effect of waste quantities accumulated at the SWDS (see below). The other city groups show a more moderate increase in emissions due to a lower population growth rate in smaller cities.

It shall be emphasised that **total sector emissions will more than double between 2015 and 2030 from roughly 19 million to 41 million tons CO_2 eq in a BAU scenario**.

The present method for estimation of emission is based on FOD method recommended by IPCC (2006) which considers the fact that CH_4 generation potential of the waste that is disposed in a certain year will start emitting in the following year and keep emitting significantly over the next years when however its emissions decrease exponentially (as per FOD method) over the time period ("effect of waste quantities accumulated at the SWDS"). Roughly, the waste deposited during the last decade will still have significant emission impact in a given year, while the waste deposited before the last decade will have a small impact on the emissions.

9 Please refer to the input sheet and calculation sheets prepared for each city groups for more information (will be made available at request).

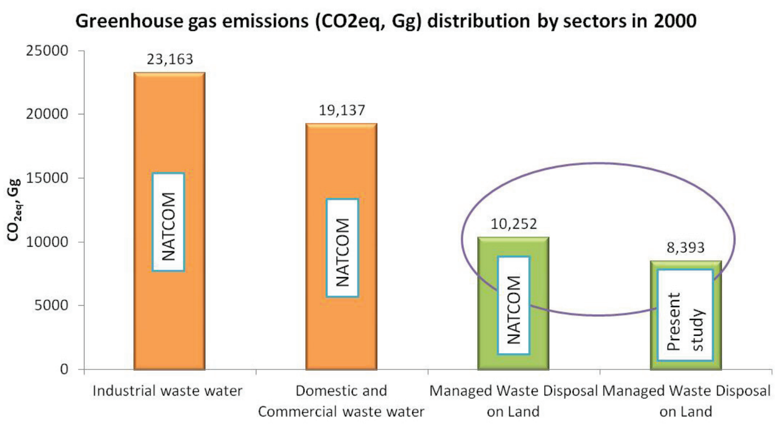
Emission intensity also varies with MCF number applicable for the identified city groups. City groups with lower MCF value have lesser emissions compared to city groups with higher MCF values. Lower MCF values mean shallow landfill sites with mostly aerobic decomposition. For example, the city group above 5 million inhabitants has a high MCF value (0.80) compared to the city group with a population between 1 million to 5 million (MCF value is 0.70). This is the reason for the large emissions from the city group above 5 million inhabitants compared to the city group with a population between 1 million to 5 million for a similar population size in 2030.

In the present study, it has been assumed that the amount of waste treated belongs to the city group with more than 5 million inhabitants. Hence the treated quantity of waste has been deducted from the total waste quantity generated from the city group with more than 5 million inhabitants Therefore, emissions from the city group with more than 5 million inhabitants decreases after 1994. It further increases with the rapid increase in population.

The result shows that GHG emissions from solid waste disposal are going to double by 2030 from present level i.e. 2015, until 2030. It is also evident that the cumulative emissions from city groups with more than 1 million inhabitants will contribute more than 50% of total emission by 2030. As per McKinsey Global Institute (2010), there will be 68 cities of this type by 2030. Hence these cities should be targeted first under the SWM NAMA.

The present estimate provides value of GHG emission in 2000 which is 20% lower compared to MoEF's (2011) estimate for emissions from managed waste disposal on land (8.3 compared to 10.3 million tons CO_2 eq.). The GHG emission result of this study has been compared with emissions from other waste sectors as estimated by MoEF (2011) in Figure 15.

Figure 15: Comparison of SWM-related emissions with emissions from other waste types estimated under 2nd National Communication (kt CO2 eq)



2.2.7 Step 8: Explanation of the differences to data from the 2nd National Communication

MoEF (2011) provides GHG emission estimates for industrial waste water, domestic and commercial waste water and managed waste disposal on land. The GHG emission from managed waste disposal on land is based on waste generation of 0.55 kg/capita/day (ibid, p. 76). The discussion suggests that this emission refers to emissions from MSW only ("It is quite reasonable to assume that the waste quantity is proportional to urban population for estimation, in the absence of data, by year";" Extensive studies on quantity and composition of municipal solid waste are available which serve as the basis for the estimation of CH_4 at the national level") and does not consider industrial solid waste or agriculture waste (IPCC, 2006).

MoEF (2011) has estimated GHG emissions from landfill sites for the year 2000 based on the FOD method recommended by IPCC (2006). The GHG emissions have been estimated for urban India. The past 50 years population data has been used as proxy to estimate the quantity of waste disposed. The study does not consider the emissions avoidance from biological treatment of waste whereas the same has been considered in the present analysis. MoEF (2011) does not provide any future forecast for GHG emission from waste disposal.

The present analysis is based on a bottom up approach where country specific data (wherever possible) has been used for each city group whereas MoEF (2011) uses one default value for the whole country for each parameter. In general its report does not provide sufficient basis for its estimation of input parameters and hence it is difficult to provide further assessment of their choice of parameters.

Table 18: Comparison of DOC value

City group	20,000 to 100,000	100,000 to 500,000	500,000 to 1 million	1-5 million	Above 5 million	MoEF (2011)
Food	15%	15%	15%	15%	15%	11%
Garden	20%	20%	20%	20%	20%	
Paper	40%	40%	40%	40%	40%	
Wood	43%	43%	43%	43%	43%	
Textiles	24%	24%	24%	24%	24%	
Nappies	24%	24%	24%	24%	24%	

MoEF (2011) does not provide DOC for the entire waste composition and it has used overall lower values of DOC which results in lower GHG emissions.

Table 19: Comparison of methane generation rate

City group	20,000 to 100,000	100,000 to 500,000	500,000 to 1 million	1-5 million	Above 5 million	MoEF (2011)
Food	0.40	0.40	0.40	0.40	0.40	0.17
Garden	0.17	0.17	0.17	0.17	0.17	
Paper	0.07	0.07	0.07	0.07	0.07	
Wood	0.035	0.035	0.035	0.035	0.035	
Textiles	0.07	0.07	0.07	0.07	0.07	
Nappies	0.17	0.17	0.17	0.17	0.17	

MoEF (2011) has used methane generation rates equivalent to methane generation rate from garden waste or nappies. This is lower than the methane generation rate applicable for food. Hence a lower methane generation rate will result in lower GHG emissions.

Table 20: Comparison of MCF

City groups	MCF
20,000 to 100,000	0.4
100,000 to 500,000	0.4
500,000 to 1 million	0.5
1-5 million	0.7
Above 5 million	0.8
MoEF (2011)	0.4

MoEF (2011) has used 0.4 as a MCF which is applicable for an 'unmanaged - shallow' (<5m) type of landfill. This value is lower than MCF values used in present study. A lower MCF value will result in lower GHG emissions.

Table 21: Comparison of waste generation rate and generation to collection ration

City groups	gram/capita and day	Generation to collection ratio
20,000 to 100,000	349	50%
100,000 to 500,000	375	60%
500,000 to 1 million	411	65%
1-5 million	423	70%
Above 5 million	485	80%
MoEF (2011)	550	70%

Waste generation rates used by MoEF (2011) are significantly higher than the waste generation rates estimated in the present study. This gap further widens after considering the annual growth in waste generation rate. This will result in higher GHG emission compared to the present estimation.

Comparison of waste composition and other parameters: The present analysis is being carried out based on detailed waste composition data whereas MoEF (2011) analysis is not based on detailed waste composition data. Other parameters are taken from IPCC (2006) in both models (MoEF (2011) and present model).

The above analysis suggests the following main reasons for the present study´s lower estimation of GHG emission for the year 2000, compared to MoEF (2011) estimation:

1. The present analysis does not cover smaller cities (with less than 20,000 populations) whereas MoEF (2011) covers total urban population (this includes smaller cities as well).
2. The waste generation rate considered by MoEF (2011) is much higher compared to the present estimate. MoEF (2011) considers waste generation rate as 550 gram per capita in 2000 whereas waste generation rate varies from 349 to 485 gram per capita and day in present estimate for 2014. The gap further widens after considering the annual growth rate in waste generation rate.
3. In the present estimate, the average generation to collection ratio has been considered as 65% whereas MoEF (2011) has considered this ratio as 70%. Higher collection ratio will give more emission from waste disposal.
4. MoEF (2011) does not consider the emission avoidance from biological treatment of waste whereas the same has been considered in present analysis.

The above comparison shows that the difference in parameters except waste generation rate and collection ratio results in lower GHG estimation by MoEF (2011).

Hence the GHG emission estimated by MoEF (2011) for 2000 is higher compared to the present study mainly due to coverage of total urban India (including smaller cities), with no waste treatment and higher waste generation rate and collection ratio.

3 Criteria and indicators for assessment of GHG mitigation options in Indian SWM

3.1 INTRODUCTION

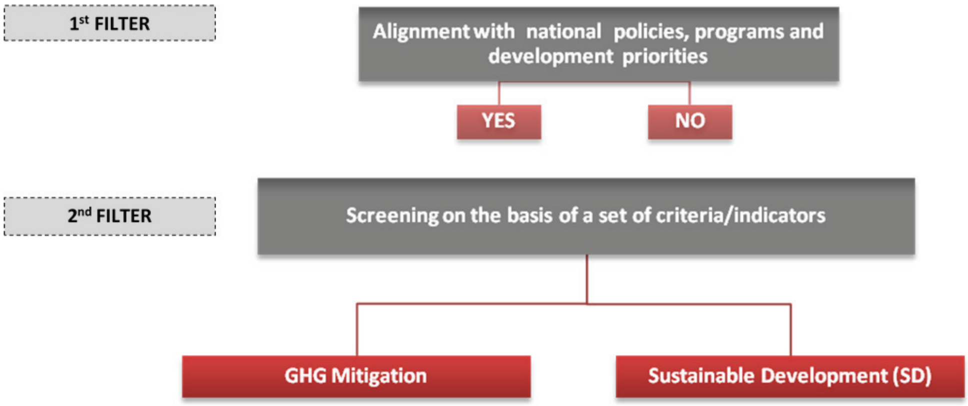
This framework of criteria and indicators is developed to screen plausible NAMA options from a list of available policy and/or mitigation options in order to check if these options meet the mitigation and sustainable development goals of GoI and also meet the requirements of international credibility and acceptability. The identified NAMA options are proposed to undergo a two-level screening as shown in Figure 16.

Table 22: Indicative list of national policies in India, focusing on SWM

1.	NAPCC
2.	Guidelines on Swachh Bharat
3.	MSW Manual (Revised) – CPHEEO
4.	MSW Rules 2000 (revised 2014)
5.	MNRE – WTE policies

The first filter ensures that the NAMA option is aligned with the existing national and sectoral policies and development priorities (see table on the right). Each NAMA option will be checked regarding its consistency with the policies mainly to avoid any conflict from the policies. If there is a positive response, only then the further level of check is applied to determine the contribution to sustainable development of the proposed option. In the second filter a list of suitable and appropriate NAMA options is mapped as per the defined criteria and indicators. The 2-step approach helps in coherently prioritising relevant NAMA options from the entire list of available NAMA options.

Figure 16: Screening levels of the proposed framework of criteria and indicators



In 2005, GoI set up the National CDM Authority (NCDMA) to approve CDM projects in India. Its key task was to define criteria for the sustainable development contribution of such projects. This is based on Article 12.2 of the Kyoto Protocol which defines the objectives of CDM as follows: *"The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving* ***sustainable development*** *and in contributing to the ultimate objective of the Convention, and to assist Annex I countries in achieving compliance with their quantified emission limitation and reduction commitments under Article 3."* Therefore, for CDM to achieve its dual objectives, examination of the sustainable development (SD) attributes of projects becomes very critical. India is one of the major actors in the CDM and has registered 1,544 projects under the CDM out of which 50 projects are registered within the waste sector (UNEP DTU, 2015a). Of these, 19 projects are related to MSWM. The approach of the NCDMA in assessing SD has changed over time, as policymakers have learned from experiences with implementation of projects (see below).

It is common practice evaluating project activities regarding their contribution to SD based on a framework of criteria and indicators. According to the Oxford dictionary, a criterion is a principle or standard by which something may be judged or decided. An **indicator** on the other hand is a **quantitative or qualitative** factor or **variable** that points out the state or level of the criterion by defining benchmarks or establishing baselines from which progress can be monitored. An extensively quoted criteria set was put forward by the United Nations Statistical Institute for Asia and Pacific. According to these criteria, an indicator needs to be SMART: Specific, Measurable, Achievable, Relevant and Time-related (UNDP, 2009). The indicator selection process in this research has been performed in line with these criteria.

3.2 DEVELOPMENT OF A FRAMEWORK OF CRITERIA AND INDICATORS FOR SCREENING AND PRIORITISATION OF INTERVENTIONS IN SWM IN INDIA

The following section provides a review of most relevant frameworks of the criteria & indicators available for screening of the contribution to sustainable development. Appendix 3 provides a detailed list of the frameworks referred for development of the proposed set of criteria & indicators.

3.2.1 NCDMA approach in India

The set of guidelines released by the NCDMA emphasises that "CDM projects should be oriented towards improving the quality of life of the poor from the environmental standpoint" (National CDM Authority, 2009). According to NCDMA, below aspects should be taken into account when designing CDM project activity:

- **Social well-being:** The CDM project activity should lead to alleviation of poverty by generating additional employment, removal of social disparities and contribution to provision of basic amenities to people leading to improvement in quality of life of people.
- **Economic well-being:** The CDM project activity should bring in additional investment consistent with the needs of the people.
- **Environmental well-being:** This should include a discussion of impact of the project activity on resource sustainability and resource degradation, if any, due to proposed activity; bio-diversity friendliness; impact on human health and reduction of levels of pollution in general.
- **Technological well-being:** The CDM project activity should lead to transfer of environmentally safe and sound technologies that are comparable to best practices in order to assist in upgradation of the technological base. The transfer of technology can be within the country as well from other developing countries also.

Recently, NCDMA has expanded the sustainable development criteria/indicators and prescribed a detailed list of these indicators (Appendix 4). The scoring of each of the SD indicators is done as negative (-1), neutral (0) or positive (+1).

3.2.2 UNFCCC SD Tool

'The UNFCCC's voluntary tool for describing sustainable development co-benefits of CDM project activities or programmes of activities (PoA') i.e. the UNFCCC SD Tool (*Version 01.1*) is an online tool for highlighting the SD benefits of the CDM (UNFCCC, 2014a). It is applied on a voluntary basis by the CDM project developers in a "structured, consistent, comparable and robust manner" by responding to a checklist of predefined indicators that illustrate impacts on the environment, society and economy of CDM host countries. The tool is divided into following three sections:

- Section 1: Project Activity
- Section 2: Sustainable Development Co-benefits
  - Environment – Air, Land, Water, Natural Resources
  - Social – Jobs, Health & Safety, Education, Welfare
  - Economic- Growth, Energy, Technology Transfer, Balance of Payments
- Section 3: Third Party Assessment

The scoring of each of the SD indicators is done as "none, highly, partly, slightly".

3.2.3 The Gold Standard

The Gold Standard is a standard for developing emission reductions projects of high quality in the CDM, Joint Implementation (JI) and Voluntary Carbon Market. Ensuring appropriate safeguards, it ascertains that carbon credits are not only real and verifiable but make measurable contributions and foster sustainable development in the communities where projects take place. Annexure 4 provides the details on the principles of Gold Standard (Gold Standard, 2013).

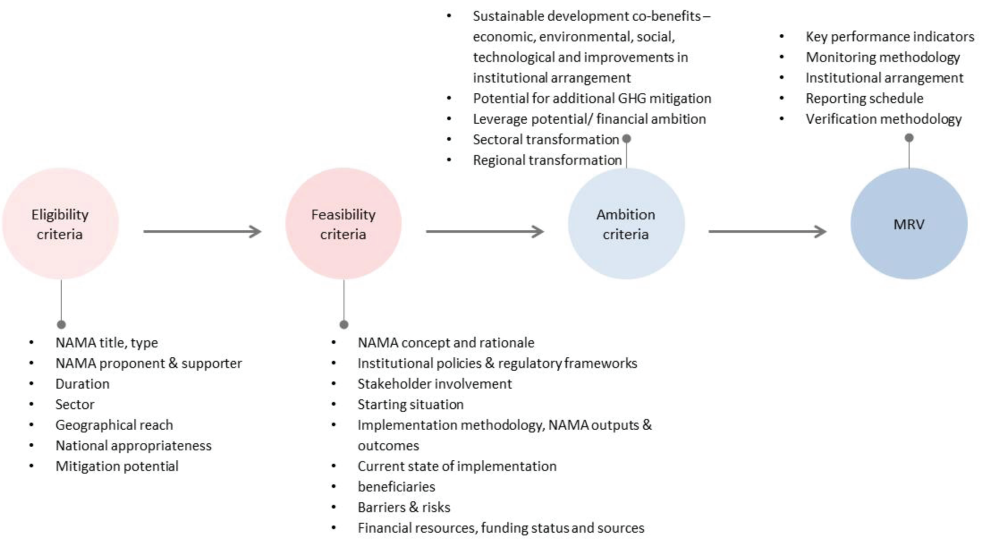
The Gold Standard (GS) uses a widely known, tested and accepted matrix approach consisting of 12 SD indicators in three categories: environment, social and technological/economic development (Ecofys, TÜV-SÜD and FIELD, 2008). Project participants score each of the SD indicators as negative (-1), neutral (0) or positive (+1). All indicators are given the same weight. Scoring is supported by convincing argumentation for each indicator by referring to publicly available information sources or expert opinion. Most of the submissions support the GS matrix approach, some with slight modifications such as adding a few indicators, adding project-specific SD requirements, or including safeguard principles in the list of SD indicators.

3.2.4 GIZ's template for formulation of NAMA

The template by GIZ for formulation of NAMA seeking support for its implementation is a very useful document demonstrating a framework for providing tailor-made climate finance for developing countries in the field of mitigation (Appendix 7). The structure of the template is in line with the requirements of the UNFCCC NAMA Registry and the NAMA Facility. There is focus on the following aspects while considering a NAMA for support:

- Focus on low carbon development and GHG mitigation
- Potential for sectoral transformation
- Sustainable development; and
- Developing capacities in the host country

Figure 17: GIZ/KPMG NAMA criteria



We do not apply this approach in its entirety as we see it as extremely heavy due to its multiple layers. The sequence of steps in our view is only partially justified. There is duplication - mitigation potential is to be assessed both on step 1 and 3, which is captured by the proposed C&I framework through this study.

MRV is an important aspect of a NAMA and is critical especially for an internationally supported NAMA, as the donor has a strong interest in achieving mitigation performance. However, MRV-ability is not a separate screening criterion in the proposed C&I framework as it would be defined indirectly by the MRV-ability of the indicators used for measuring the impacts of a NAMA.

Similarly, operationalization of the "transformation" criterion is highly challenging, especially since transformational changes or impacts are only observed over a long time span. Therefore, in this study, assessment of GHG mitigation potential of the different NAMA options is used as a criterion instead.

3.2.5 Green Climate Fund

The Green Climate Fund – mentioned in the Copenhagen Accord and constituted in 2010 (at 16th COP in Cancun) -, is a legally independent institution within the framework of UNFCCC established to support efforts of developing countries in limiting or reducing their emissions and adapting to the impacts of climate change. The GCF has received pledges of around USD 9 billion and is envisaging to receive the first funding proposals by July 2015.

The GCF Board is set to consider those options which better enable national and sub-national institutions of developing countries to access, oversee and manage funds. For example, the Board will consider adjusting the procedures used to facilitate direct access to GCF finance depending on the "nature, scale and risks" of the proposed project or programme (GCF Board, 2014b).

The C&I, minimum benchmarks, and various methodologies on which the decision to support specific proposals and to fund a specific activity are set by the Board and are in the process of evolution. The framework will undergo modifications from time to time, as appropriate since several important components of the Fund will require further development in the coming months.

Criteria as proposed by GCF (GCF Board, 2014a) belong to six broad categories, and are differentiated between mitigation and adaptation, as appropriate. Currently, the criteria are as follows (ibid.): (1) Impact potential; (2) Transformational potential; (3) Needs of beneficiary country/region; (4) Institutional capacity of beneficiary; (5) Economic efficiency of activity; and (6) Financial viability of activity (for revenue-generating activities). Appendix 8 provides details of GCF's criteria with examples.

This study's C&I framework reflects most of the GCF's criteria and indicators and therefore would be helpful in prioritisation of those NAMA options that are competently viable in leveraging the financial support through GCF for their implementation.

GCF till date does not give clear definition on what a transformational change towards sustainable low-emission development might mean. But, the definition is expected to be circumstantial i.e. driven mainly by means of funding priorities and is expected to be adjusted as knowledge evolves. Transformational change as well as the objective of change is characterised by the process. The process towards low-emission development must be self-reinforcing, and the goals of this process must contribute to long-term sustainable development. As shown by the lack of examples for indicators in GCF (2014b) for "Transformational potential", this concept is extremely difficult to operationalise. In our view can be captured by assessing the GHG mitigation achieved in the very long term – as the transformational impact is shown if over a long period of time emissions mitigation increases – and hence is covered by the Criteria & Indicator proposed by the study.

The GCF's criteria on "Needs of the Beneficiary" is defined as the "*degree to which a beneficiary needs the finance more than others, or is relatively less capable than others to fulfill this need through other funding sources"* (GCF 2014a). This criteria is more relevant from GCF Board's point of view in terms of making a country-level comparison and is not so relevant in terms of screening of NAMA options proposed through this study and so is not incorporated in the proposed C&I framework.

For the finalised NAMA option, an institutional capacity assessment is a necessity and would anyways be carried out to assess the readiness of the institutions responsible for a successful implementation of a NAMA option. Hence, this aspect is in line GCF's criteria on "Institutional Capacity" proposed by the study.

The proposed C&I assesses and compares the probable NAMA options based on their bankability and thus capture the elements mentioned under GCF's Financial and economic criteria.

3.2.6 NAMA Facility

The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Department of Energy and Climate Change (DECC) of the United Kingdom collectively established the NAMA Facility (in 2012 in Doha, Qatar) and contributed jointly an initial funding of EUR 70 Million to support developing countries and emerging economies that demonstrate leadership on dealing with climate change and that want to implement aspiring climate protection measures (NAMAs). The Facility applies the following criteria, all of which are greatly oriented towards the experiences with development collaboration (NAMA Facility, 2014):

- Eligibility criteria
- Ambition criteria
- Feasibility criteria

The eligibility criteria are all related to the organisational aspects of the NAMA submitter, such as the endorsement by the host country government, collaboration with a qualified delivery organisation, readiness to start NAMA implementation, an adequate time frame, the concept for phase out of international support. Most of these criteria are not really relevant for a national government that can control who submits a NAMA proposal.

The ambition criteria are most close to the criteria applied in the CDM and by the GCF

- Potential for transformational change
- Sustainable development co-benefits
- Financial ambition
- Mitigation ambition

The financial ambition criterion aims at maximising leverage of the support.

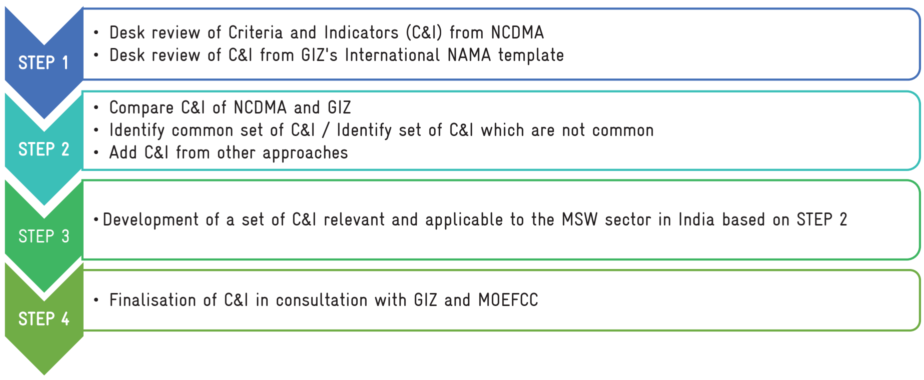
Finally, the feasibility criteria focus on the design of the "NAMA project", i.e. the activity that seeks financing from the NAMA Facility. This should not be confused with the actual NAMA. Here, national and international embeddedness, project structure, project finance, and the used log frame are assessed. Again, a NAMA fully controlled by a national government does not require such an assessment, because it is not framed as a "project".

The NAMA Facility does not specify any indicators for its criteria set; candidates are thus free to interpret the criteria in various ways. Our C&I set focuses on co-benefits and mitigation ambition. The "transformational change" suffers from the same problems.

3.2.7 Summary of the approach applied to develop the proposed framework of C&I

Given the available sets of criteria and indicators, we start from the set used by the National CDM Authority (NCDMA) and complement it by selected criteria and indicators from the GIZ set. The following steps (Figure 18) have been undertaken to arrive at the final set of criteria & indicators for screening and prioritizing the NAMA options for the SWM sector in India.

Figure 18: Steps for development of list of criteria & indicators for screening of NAMA options

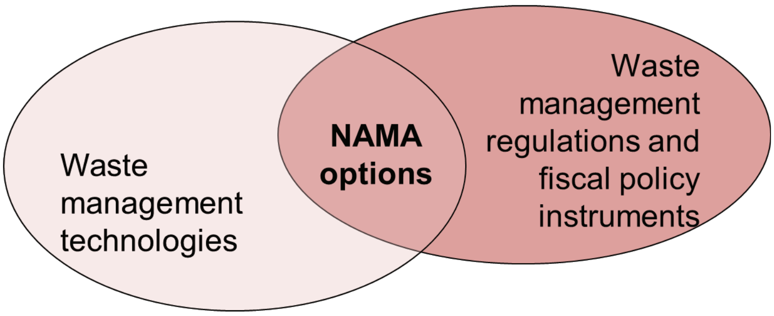


The NCDMA framework is considered as core on which the proposed set of C&I is based. Given the expected local implementation of this framework, one can assume that a framework primarily based on the NCDMA framework would be able to achieve broad acceptance within the country. Since the NCDMA framework is covering a large number of sustainable development C&I - not just for the waste sector - but for other sectors too, only C&I relevant to this study are retained and the others are dropped. Thereafter, a similar exercise was carried out for selecting suitable C&I from GIZ's international template for NAMA formulation. Subsequently, the C&I proposed by NCDMA and by GIZ were compared to identify which ones have been applied in both the frameworks and a list of the same was prepared.

In the subsequent step, an exhaustive customised list of C&I for screening the NAMA options in waste sector was prepared also including further approaches to C&I as listed in Appendix 5 and its consistency with respect to NCDMA's and GIZ's framework was checked. This list will be finalised based on discussions with GIZ and MoEFCC.

It should be noted that the NAMA options to be evaluated against the set of C&I are not only determined by various technologies applicable to the treatment of waste but rather by the implementation of waste management policies and regulations. Accordingly, the indicators should be interpreted in a way of asking how waste management policy instruments improve sustainable development. Does the policy instrument promote, trigger or result in sustainable development in the sense of the specific indicator? This evaluation is by far more complex as the evaluation of single project activities or waste technologies, but finally required for a successful NAMA implementation.

Figure 19: Constitution of NAMA options



3.3 FINAL SET OF CRITERIA AND INDICATORS

3.3.1 Criteria & indicators

The final set of C&I has 5 categories, 21 criteria and 30 indicators (Table 24 – Table 28 below). The GHG criteria means screening of options based on their mitigation potential. The Non-GHG criteria involve sustainable development (SD) elements i.e. social, economic and environmental, technological.

Table 23: Numbering system

	Represented by	Total
Category	I II III IV V	5
Criteria	A B C D	21
Indicators	A.1, A. 2, A.3; B.1, B.2	30

Table 24: Criteria and indicators for GHG mitigation potential parameter

SN	Criteria	Description	SN	Indicator
I.A	GHG mitigation potential (direct and indirect)	Mitigation potential is the level of GHG emission reductions that could be realised, relative to the projected emission baseline in a given year	I.A.1	Annual average emission reduction over a period of five years in tons CO2 eq (short term)
			I.A.2	Cumulated emission reduction over a period of 10 years in tons CO_2 eq (mid term)
			I.A.3	Cumulated emission reduction over a period of 20 years in tons CO_2 eq (long term)
I.B	Abatement cost of technologies involved in the NAMA option	Whether the technology/set of technologies is the least cost option	I.B.1	Abatement cost per tonne of CO_2 eq mitigated

Table 25: Criteria and indicators for sustainable development – technology parameter

SN	Criteria	Description	SN	Indicator
II.A	Maturity of technologies – global markets	Whether technologies are globally recognised, has been implemented and is successful anywhere globally	II.A.1	No. of projects implemented globally using the technologies in the past 5 years
II.B	Adaptability of technology to domestic requirements – technical feasibility	Whether technologies are conducive to national circumstances – climate, waste quantity and composition	II.B.1	Meets the local technical requirement of waste type
			II.B.2	Meets the national environmental standards
II.C	Transfer of technology to the country	Whether NAMA option promotes technology transfer to the country	II.C.1	Is technology transferred that has not yet been implemented in India?
II.D	Promotes use of indigenous technology	Whether technologies are available locally	II.D.1	Is technology applied that has been produced in India?
II.E	Ease of implementation	Whether there is local know-how/ past experience	II.E.1	Is technology applied that has been implemented in India in the past?

Table 26: Criteria and indicators for sustainable development – economic parameter

SN	Criteria	Description	SN	Indicator
III.A	Bankability – cost-benefits	Whether projects mobilised under the NAMA option are bankable options with returns above current cost of capital	III.A.1	Equity IRR/NPV
III.B	Leverage of private sector finance	Whether NAMA option has the potential to leverage private sector finance	III.B.1	Leverage multiple
III.C	Improve balance of payments by reduced foreign exchange outgo	Whether NAMA option promotes direct or indirect saving of foreign exchange outgo	III.C.1	Foreign exchange saved (direct & indirect) equivalent

SN	Criteria	Description	SN	Indicator
III.D	Costs savings/ avoided costs/ deemed or direct revenue	Whether NAMA option generates direct or deemed income to ULBs against the alternatives	III.D.1	Deferred or avoided infrastructure costs/ Reduced cost of treatment Additional revenue e.g. though taxes, sale of by-products
III.E	Efficient utilisation of resources - Promotes sustainable usage of national natural resources	Whether NAMA option uses less of land, electricity, water or promotes lower use of natural resources	III.E.1	Physical footprint
			III.E.2	Energy footprint
			III.E.3	Water footprint
III.F	Markets	Whether markets exist for by-products	III.F.1	Electricity
			III.F.2	Compost
			III.F.3	Biogas
			III.F.4	Syn gas
			III.F.5	RDF
III.G	Job creation - direct in the waste management value chain	Whether NAMA option generates direct employment opportunities and promotes economic activity	III.G.1	No. of people employed in projects triggered by the NAMA option
III.H	Job creation - indirect due to enhanced economic activity	Whether NAMA option generates indirect employment opportunities and promotes economic activity	III.H.1	No. of people engaged in induced economic activity

Table 27: Criteria and indicators for sustainable development - social parameter

SN	Criteria	Description	SN	Indicator
IV.A	Formalisation of unorganised sector - waste management value chain	Whether the NAMA option promotes skill development of personnel from unorganised sector e.g. waste pickers, household collection personnel	IV.A.1	No of personnel engaged in skilled jobs

Table 28: Criteria and indicators for sustainable development - environmental parameter

SN	Criteria	Description	SN	Indicator
V.A	Impact on air	Whether projects triggered under the NAMA option meet the Central Pollution Control Board (CPCB) or State Pollution Control Board (SPCBs) norms on air pollution control	V.A.1	Projects meets the national environmental standards
V.B	Impact on water - quality of water in ground or surface water, underground water, coastal water - availability & accessibility of water	Whether projects triggered under the NAMA option meet the CPCB or SPCBs norms on water pollution control	V.B.1	Projects meet the national environmental standards
V.D	Improvement in soil fertility	Whether projects triggered under the NAMA option provide fertiliser	V.C.1	Fertiliser production from project

SN	Criteria	Description	SN	Indicator
V.D	Impact on noise pollution – due to use of plant & machinery	Whether projects triggered under the NAMA option meet the CPCB or SPCBs norms on noise pollution control	V.D.1	Projects meet the national environmental standards
V.E	Comparison with waste hierarchy	Whether waste hierarchy is being followed and what stage the option is at prevention, re-use , recycling	V.E.1	Projects higher in the waste hierarchy get better ranking

Each criterion is disaggregated in a number of criteria and indicators. A detailed Excel sheet has been prepared for the same that is available upon request.

3.3.2 Scores and weights for indicators

Once the above filters are applied to available NAMA options, then a ranking is developed of all options. Generally, the indicators are partially qualitative or quantitative. The scoring scale used for each criterion could be in the form of:

Table 29: Evaluation schemes

SN	Description	Scoring options	Scoring
S1	Effect/contribution of NAMA option to criterion/indicator?	High Medium Low	+2 +1 0
S2	Effect/contribution of NAMA option to criterion/indicator?	Positive Neutral Negative	+1 0 -1
S3	Criterion/indicator fulfilled?	Yes No	+1 -1
S4	Ranking: a) Level increased: Yes by or to x% b) Level decreased: Yes by or to x% c) Ranking based on criterion/indicator (e.g. waste hierarchy).	Best option(s) Second best option(s) Third best option(s)	+2 +1.5 +1

The Indian NCDMA uses **Positive, Neutral and Negative** scores for assessment of criteria in its new guidelines.

A defined scoring & weightage criteria would therefore, provide guidance to structure the process of screening and prioritization of potential NAMAs options in India's waste sector. All the identified potential NAMA options can be ranked according to the scoring and weightage of each indicator (30) to be decided in consultation with MoEFCC.

Table 30: Screening table for NAMA options

Evaluation Criteria	GHG Mitigation Potential	SD – Economic	SD – Social	SD – Environmental	SD – Technology	Total Score	Ranking
NAMA Option 1	Insert score	Insert score	Insert score	Insert score	Insert score	Total score	Indicate rank

4 Identification of mitigation policies, programmes and projects that could become part of an Indian SWM NAMA

4.1 INTRODUCTION

Improved waste management in India faces several challenges and barriers to implementation. These challenges comprise of policy, institutional, technological, financial and capacity issues which need to be dealt with. The proposed NAMA options should help overcome these challenges and barriers to facilitate accelerated implementation of waste management projects and programmes in the country.

In order to identify NAMA opportunities for the waste sector in India, the relevant documents and data that deliver country context, information on GHG emissions, government priorities, and on-going and planned actions in the waste sector have been reviewed. In addition to the secondary research, stakeholder consultations have also been carried out. Analysis of each of these provides direction towards pointing out potential NAMA options.

Besides policies and programmes, a review of CDM projects is undertaken to review the familiarity of the country through various actors in mitigation activities in the waste sector. Finally, a review of NAMAs in waste sector proposed by various countries is also carried out. This information provides a global perspective on identified NAMAs in the sector.

4.2 REVIEW OF POLICIES, PROGRAMMES AND CDM PROJECTS IN THE INDIAN SOLID WASTE SECTOR

In this section, a detailed review of key policies, programmes and other initiatives (as indicated in Section 2) in the solid waste sector of India is carried out in order to understand their current status.

An understanding developed from the review of sectoral policies and programmes indicates that there exists a sound policy framework for supporting NAMAs in waste sector in India.

4.2.1 Key policies and programmes in the solid waste sector

In this section, a number of policies, programmes and initiatives in the solid waste management sector in India have been reviewed. The same are listed below.

- Service Level Benchmark
- Swachh Bharat Abhiyan / Clean India Mission
- Smart Cities Initiative
- JNNURM – I
- National Mission on Sustainable Habitat (NMSH)
- MSW Manual (Revised) – Central Public Health and Environmental Engineering Organisation (CPHEEO)
- MSW Rules 2000 (2014)
- Ministry of New and Renewable Energy (MNRE) - WTE policies

These policies and programmes are detailed in the following section for their objectives and key goals, current status as well as key challenges faced. From the review, it becomes clear that there exists a strong policy framework which would be well placed to support NAMA in the waste sector in India.

Service Level Benchmark (SLB)

Initiated by: Ministry of Urban Development (MoUD), Government of India in 2009

Introduction: Benchmarking is a vital tool for introducing accountability in service delivery in all cities. Continuous benchmarking can help Urban Local Bodies (ULBs) and utilities in finding performance gaps and implementing improvements through the sharing of information and best practices and finally bringing better services to people. Recognising its importance, the MoUD has launched Service Level Benchmarking (SLB) covering water, sanitation, solid waste management and storm water drainage for all JNNURM mission cities.

Key goals related to solid waste management in cities:

- Household Level Coverage 100%
- Efficiency in Collection of Solid Waste 100%
- Extent of Segregation of MSW 100%
- Extent of MSW Recovered 80%
- Extent of Scientific Disposal of MSW 100%
- Extent of Cost Recovery 100%
- Efficiency in Collection of SWM Charges 90%
- Efficiency in Redressal of Customer Complaints 80%

Status:

- It is introduced in 30 states and across 1700 ULBs.
- Performance-related funds under the 13th Finance Commission have been linked to improvements in SLBs including SWM.

Limitations/challenges in its implementation:

- The data at city/ULB level can be credible and reasonably accurate only if, they have been captured on a regular basis at the lower levels, such as the ward level. However, systems for capturing key data elements identified for SLB are not present in many cases at the field level.
- Performance management will be sustainable only if disclosure, reporting, monitoring and performance management feedback, incentives and disincentives are also brought into the cycle. Else the system of measurement and disclosure of SLBs may not sustain itself.

More details available at: http://moud.gov.in/servicelevel

Swachh Bharat Abhiyan / Clean India Mission

Initiated by: Government of India on 2 October 2014

Introduction: Swachh Bharat Abhiyan is a national level campaign by the GoI, covering 4,041 statutory towns with the ambitious target of complete sanitation which includes eliminating open defecation and smart management of both solid and liquid waste throughout the country. This campaign aims to accomplish the vision of 'Clean India' by 2 October 2019, 150th birthday of Mahatma Gandhi and is expected to cost over USD 10.3 billion (INR 620 billion)(Ministry of Urban Development, 2014). The fund sharing between the Central Government and the State Government/ Urban Local Bodies (ULBs) is 75%:25% (ibid).

Key goals related to solid waste management:

- 100% collection and scientific processing/disposal/reuse/recycle of municipal solid waste
- 20% VGF available for solid waste management
- States to provide VGF on sharing or additional basis
- Eradicate manual scavenging of waste
- Strengthen of urban local bodies to design, execute and operate systems
- Create an enabling environment for private sector participation in capital expenditure and operation & maintenance (O&M) costs
- Ensure solid & waste disposal systems and clean village
- 3% of the total allocation for the mission will be earmarked for the purpose of extensive capacity building activities which will be brought out separately in consultation with the States.

Status:

- The Swachh Bharat Mission is divided into two components – SBM Gramin (rural) and SBM Urban. The guidelines are available on the website of the Ministry of drinking water and sanitation and on Ministry of Urban Development website for rural and urban component, respectively.
- The Centre will soon develop an appropriate statistical framework to assess progress made on the ground in the Swachh Bharat Abhiyan.
- The government in order to assess the progress of the Mission will bring out a **Swachhta Status Report** (Sharma 2014)[10] every year starting from 2016 after carrying out extensive surveys.

Limitations/challenges in its implementation:

Just like Smart Cities, this new policy initiative is still unraveling. Logically, this initiative would be part of an overall smart city effort of GoI.

More details available at: http://moudulbs.nic.in/ISNAHome.aspx

Smart Cities

Initiated by: Government of India (GoI) on 25 September 2014

Introduction: The Indian government has recently launched Smart Cities programme to build 100 smart cities across India. The aim is to integrate technology into the system to offer more structured and hospitable living conditions for residents. The concept of Smart cities has several verticals like smart transportation, smart waste management, smart energy, smart buildings etc.

Smart City plan is part of a larger agenda of creating industrial corridors between India's big metropolitan cities. These include the Delhi-Mumbai Industrial Corridor, the Chennai-Bangalore Industrial Corridor and the Bangalore-Mumbai Economic Corridor. Along these corridors, the hope is that several industrial and commercial centres will be reinvented as "Smart Cities". The Delhi-Mumbai Industrial Corridor (DMIC) is spread across six states and aims to create seven new smart cities as the nodes of the corridor in its initial phase.

Key goals related to solid waste management:

- 100% households are covered by daily door-step collection system
- 100% collection of municipal solid waste
- 100% segregation of waste at source, i.e. biodegradable and non-degradable waste
- 100% recycling of solid waste

10 After developing the methodology, a three-month survey was conducted during November 2014 to January 2015, followed by series of data collection works. Finally, the first Swachhta Status Report will be made available by January 30, 2016.

- Segregation of recyclable and non-recyclable waste as well as wet and dry waste at the source so that there can be 100% recycling of solid waste
- Appropriate technology should be adopted for treatment of waste at decentralised locations
- Put in place an effective collection and disposal system
- Inspire use of products based on recycling of solid waste in particular – power, compost, building material (based on cycling of debris & construction materials)

Status:

GoI has allocated USD 1.2 billion (INR 70.6billion) (PRNewswire, 2015) for Smart Cities in Union Budget in 2014-15. However, it is anticipated that most of the infrastructure will developed either as full private investment or through PPPs. The contributions from the GoI and States/ULBs will be largely by way of Viability Gap Support (VGF).

Japan is helping India develop its smart cities by investing USD 4.5 billion (Idiculla, 2014) in the first phase of the Delhi-Mumbai Industrial Corridor (DMIC) project through lending from the Japan International Cooperation Agency (JICA). JICA has also taken up master planning for 3 "smart cities"- Ponneri in Tamil Nadu, Krishnapatnam in Andhra Pradesh and Tumkur in Karnataka - in the Chennai-Bangalore Industrial Corridor.

The United Kingdom (UK) is cooperating with India for developing the Bangalore-Mumbai Economic Corridor project which is supported by private companies from the UK.

India has also got into an agreement with Singapore to use its expertise in smart cities and urban planning for developing the 100 Smart Cities.

Limitations/challenges in its implementation:

- Smart city initiative is still at concept stage and is unfolding.
- There are no standard definitions or regulatory mechanisms for governing of smart cities.
- There are no clear appraisal mechanisms for selecting of suitable proposals.
- Mechanism/institutional structure for flow of funds is absent.

More details available at: http://indiansmartcities.in

JNNURM – I

Initiated by: GoI on 3 December 2005

Introduction: JNNURM is a reform driven, fast track programme to ensure planned development of identified cities with focus on efficiency in urban infrastructure/service delivery mechanisms and covers 65 cities and towns (Planning Commission, 2014). For the remaining 5,098 urban areas outside JNNURM, the Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) has been launched (MoUD, 2009).

Key goals related to solid waste management:

JNNURM sector-specific guidelines for SWM projects

- **Considerations in segregation at source and reuse/recycle:** Considerations/introduction of systems/bye-laws/policies and measures to improve source separation and recycling, taking into account existing formal and informal activities and the requirements of different waste re-users/ re-processors.
- **Collection and transportation system:** Establishment of an efficient secondary collection and transfer system.
- **Selection of fisposal facility:** Introduction of acceptable and reliable treatment and/or disposal system (which could include waste reuse and/or reprocessing to a product of market value (gas, energy, manure, RDF, etc.)
- **Consideration for ultimate disposal:** Identification and establishment of a technically suitable and publicly acceptable long-term landfill facility; land for MSW disposal and treatment must be identified as per MSW Rules 2000 including any amendments thereof.
- **Enabling legal framework:** The ULB shall establish an enabling legal framework for the levy of user charges and their appropriation.
- **Institutional arrangement and efficiency enhancement:** Adoption and implementation of a code of practice for operation of the MSW system; separate accounting for MSW to allow relevant costs to be identified and quantified; establishment of a technically capable unit clearly responsible for all aspects of MSW to strengthen the institutional framework for managing MSW within the ULB

- **Revenues and cost recovery:** Introduction of tariffs (user "fee" or "tax" or "betterment levies"), and/or structuring tariffs to recover O&M costs and their revisions over the project period (construction and O&M). Identify and allocate reliable source of subsidies (revenue sources) to make the projects sustainable.
- **Performance measurement and monitoring:** Performance measurement and monitoring system with quantitative performance indicators for collection, transportation, treatment and disposal.
- **Financial planning:** A realistic business plan showing estimates of annual costs and revenues, phased costs including replacement costs, capacity expansion and/or upgrading of treatment/disposal facilities, and planned improvements in performance; inclusion of sound commercial practices, with involvement of the private sector; adoption of a sustainable plan to include introduction of appropriate user charges and cess, and provision for allocating a portion of revenues towards replacement expenditure; creation of a revolving fund to provide for debt servicing and as a maintenance/replacement reserve to fund capital investments required for equipment replacement and facility expansion; cost effectiveness of proposed solutions vis-a-vis similar indicators.

Status:

- 46 MSW projects in 20 states were approved at a cost of USD 320 million (INR 19.25 billion) of which USD 120 million (INR 6.94 billion) have been released (Planning Commission, 2014).
- As on date 19 of the 46 plants supported are operational (Planning Commission, 2014).
- The extended tenure of JNNURM-I ended in 2014 and therefore second phase of JNNURM named as Atal Mission for Rejuvenation and Urban Transformation (**AMRUT**) (Dash, 2015) is proposed to be launched having a total investment of INR 2 lakh crore and 10-year duration. In addition, since over 200 projects under JNNURM are still undergoing or have been held up due to lack capital, the new scheme will have a provision of about INR 7,000-8,000 crore to finish these projects.

Limitations/challenges in its implementation:

- Wide coverage in terms of cities and population and wide scope in terms of programme components and urban reforms being implemented. Need for more detailed, disciplined and rigorous reporting, to enable effective monitoring of implementation of projects and reforms.
- Limited capacity in the state and ULBs to implement the programme.
- Second phase of Urban Renewal Mission is awaited.

More details available at: http://jnnurm.nic.in/
http://urban.bih.nic.in/Docs/JNNURM-ToolKit.pdf

National Mission on Sustainable Habitat (NMSH)

Initiated by: GoI in June 2010

Introduction: The NMSH is one of the eight missions under National Action Plan on Climate Change (NAPCC) which aims to which seeks to promote sustainability of habitats through progress in energy efficiency in buildings, urban planning, enhanced management of solid and liquid waste, modal shift towards public transport and conservation through appropriate changes in legal and regulatory framework.

Key goals related to solid waste management:

- Same ambition as highlighted above under SLBs
  - Household Level Coverage 100%
  - Efficiency in Collection of Solid Waste 100%
  - Extent of Segregation of MSW 100%
  - Extent of MSW Recovered 80%
  - Extent of Scientific Disposal of MSW 100%
  - Extent of Cost Recovery 100%
  - Efficiency in Collection of SWM Charges 90%
  - Efficiency in Redressal of Customer Complaints 80%
- Recycling of material and urban waste management under which a special area of focus will be development of technology for producing power from waste. The mission will include a major R&D programme, focusing on bio-chemical conversion, waste water use, sewage utilisation and recycling options wherever possible.

Status:

- The total funding requirement assessed for the 12th five year plan period (2012-2017) is approx. USD 153 million (INR 9.50 billion) (MoEFCC, 2014), which is to be met from existing budget of the Jawaharlal Nehru National Urban Renewable Mission (JNNURM).
- More than 50 (ibid.) capacity building programmes in various stages of implementation.

Limitations/challenges in its implementation:

Limited capacity of the officials involved in implementation to draw linkage between climate change and waste related issues.

More details available at: http://moud.gov.in/NMSH

MSW Manual – Central Public Health and Environmental Engineering Organisation (CPHEEO)

Initiated by: GoI in 2000

Introduction: Looking at the dismal situation of solid waste management practices being adopted by the ULBs in the country and having no action plan to solve the problem in future, CPHEEO – the technical wing of the MoUD and responsible for matters related to urban water supply and sanitation including solid waste management in the country – GoI prepared the Manual on "Municipal Solid Waste Management" so as to provide assistance to the user agencies in proper management of solid wastes in urban areas.

Key goals related to solid waste management:

- Step-wise guidance for MSW Plan
- Technical aspects related to collection, segregation, transportation, processing & treatment of MSW, municipal sanitary landfills
- MSWM Plan implementation (legal provisions etc.)
- Management aspects related to monitoring MSWM service provisions
- Management of special waste streams

Status:

- The manual is currently under revision.

More details available at: http://cpheeo.nic.in/

MSW Rules 2000

Initiated By: GoI

Introduction: Municipal Solid Waste (Management & Handling) Rules, 2000 (MSW Rules) **are applicable to every municipal authority** responsible for collection, segregation, storage, transportation, processing and disposal of municipal solids.

Key goals related to solid waste management:

The Rules contain four Schedules

- **Schedule-I:** relates to implementation Schedule
- **Schedule-II:** Specifications relating to collection, segregation, storage, transportation, processing and disposal of municipal solid waste (MSW).
- **Schedule-III:** Specifications for land filling indicating; site selection, facilities at the site, specifications for and filling, Pollution prevention, water quality monitoring, ambient air quality monitoring, plantation at landfill site, closure of landfill site and post care.
- **Schedule-IV:** Indicate waste processing options including; standards for composting, treated leachate and incinerations

Status:

- The MSW Rules are currently under revision. A draft has been published for seeking stakeholders' view. It is available at the following website: http://www.indiaenvironmentportal.org.in/files/file/Municipal%20Solid%20Waste%20(Management%20and%20Handling)%20Rules,%202013.pdf
- Compliance with MSW rules in terms of reporting and of technical standards etc. is still very low which could mainly be due to inadequate funds and capacities at municipal level.

Limitations/challenges in its implementation:

- Non availability of suitable land and handing over of the same to the concerned local bodies.

- Lack of technical awareness among personnels with respect to waste processing technologies, selection of proper waste processing technology with respect to waste generation and development of landfill sites.
- The local bodies in coastal area are facing the difficulties in identification of suitable land due to CRZ notifications.
- Non availability of sufficient funds with local bodies.
- Lack of public awareness/participation.
- Inadequate manpower with the Board for implementation and compliance verification with MSW Rules.

More details available at: http://cpcb.nic.in/Municipal_Solid_Waste.php

Ministry of New and Renewable Energy (MNRE) - WTE policies

Initiated by: MNRE, GoI on 12 September 2013

Introduction: The MNRE Scheme **"Programme on Energy from Urban, Industrial and Agricultural Wastes / Residues during 12th Plan period"** and with a total outlay of USD 6.3 million (INR 380 million) for the year 2013-14 (Minstry of New and Renewable Energy, 2013).

The main objectives of the programme are as follows:

To promote technology options for setting up of projects for recovery of energy from urban, industrial and agricultural wastes; and to create conducive conditions and environment, with fiscal and financial regime, to develop, demonstrate and disseminate utilisation of wastes and residues for recovery of energy

Key goals related to solid waste management:

- Setting up of five pilot projects based on MSW. In MSW to Power projects, any waste of renewable nature or biomass can be mixed to the extent of 25 % based on gross calorific value. Use of a maximum of 25 % conventional fuels would be allowed in biomass co-generation (non-bagasse) projects based on agricultural wastes and residues other than bagasse.
- Projects based on waste-to-energy conversion technologies, namely, biomethanation, combustion, gasification, pyrolysis or a combination thereof
- MSW based projects need to be developed in accordance with the decision of Hon'ble Supreme Court given during the hearing on 15 May 2007 and the recommendations of the Expert Committee referred therein.
- The projects based on biomethanation of MSW should be taken up only on segregated/uniform waste unless it is demonstrated that in Indian conditions, the waste segregation plant/process can separate waste suitable for biomethanation
- USD 0.3 million (INR 20 million) /MW (max. USD 1.5 million (INR 100 million/project) capital subsidy to be provided to the promoters generating power from municipal solid waste.
- Financial assistance would be provided for promotional activities - organising training courses, business meets, seminars/ workshops and publicity /awareness on case-to- case basis, subject to a maximum of USD 5,000 (INR 0.3million) per event/ activity.
- Financial support would be provided for R&D projects, including studies on resources assessment, technology upgradation, performance evaluation etc. to institutions/ industries. This will be governed by the procedures /guidelines issued by MNRE.

Limitations/challenges in its implementation:

- Low calorific value of waste
- Poor waste segregation and lower collection of waste than anticipated
- Inappropriate choice of technology and pricing of power
- Low financial flexibility
- Poorly structured PPP contracts and opposition from people living in the neighborhood.

More details available at: http://mnre.gov.in/schemes/offgrid/waste-to-energy/;
http://mnre.gov.in/file-manager/offgrid-wastetoenergy/programme_energy-urban-industrial-agriculture-wastes-2013-14.pdf

4.2.2 CDM project experience in the solid waste sector

India has been a very active participant in CDM, the most successful global mitigation initiative to date. India has 1,544 registered projects under CDM out of which 19 projects are registered in the field of MSWM (UNEP DTU, 2015a). India's experience from CDM on programme design, MRV system, institutional structuring among other things will help a great deal in implementation of any climate change initiative in the country including NAMA. This analysis gives an idea on the country's preparedness and its learning through CDM mechanism. Table 31 summarises the scenario of MSWM CDM projects in India (UNEP DTU 2015, see also Appendix 10).

Table 31: MSW projects in CDM pipeline from India

Parameter	No. of CDM projects
Registered CDM projects in India	1544
Registered CDM projects – MSW sector	19
Projects under validation – MSW sector	12
Validation terminated/withdrawn – MSW sector	28
Number of CDM projects with issued CERs – MSW sector	7
Registered PoA – MSW sector	0

Out of the 19 registered MSW projects in CDM pipeline,

- at least 12 projects have been commissioned whose Commercial Operation Date is available from various sources and
- only seven projects (six from composting plants and one from Power generation from RDF) have witnessed issuance albeit with low issuance success rates.

The reason for low issuance success rate is usually treatment of lower quantities (plant throughput) of MSW than the designed plant capacity. Underlying, this could be caused by non-availability of required quantities of MSW, or lower machine availability of the MSW treatment plant, which cannot be concluded based on the available information.

As per Table 32, total waste processing capacity as per Project Design Document (PDD) of the projects is 6,417 tons per day and the issuance success is higher from Mechanical Biological Treatment (MBT) projects compared to RDF projects.

Table 32: List of commissioned MSW projects from CDM pipeline and their issuance success[11]

SN	UN Ref	Title	Technology	Commissio-ning date	Location (State)	MSW (tons per day)	Issuance success[11]
1	510	Methane Avoidance by MSW Processing in the city of Chandigarh, India	RDF for industrial use	30-Mar-2009	Himachal Pradesh	500	NA
2	959	SESL 6 MW MSW Based Power Project at Vijayawada & Guntur, Andhra Pradesh	RDF for electricity generation	4-Dec-2003	Andhra Pradesh	505	42%

11 UNEP DTU (2015)

SN	UN Ref	Title	Technology	Commissio-ning date	Location (State)	MSW (tons per day)	Issuance success[11]
3	1,254	The TIMARPUR-OKHLA Waste Management Company Pvt. Ltd's (TOWMCL) integrated waste to energy project in Delhi	RDF for electricity generation	27-Jan-2012	Delhi	2,050	NA
4	1,904	Avoidance of methane emissions from MSW and Food Waste through Composting	Mechanical Biological Treatment (MBT)	1-Nov-2003	Orissa	200	51%
5	2,217	MSW based Composting at Kolhapur, Maharashtra	MBT	June 2006	Maharashtra	147	22%
6	2,470	Upgradation, Operation and Maintenance of 200 TPD Composting facility at Okhla, Delhi	MBT	24-May-2008	Delhi	200	95%
7	2,502	Upgradation and expansion of A.P.M.C compost plant at Tikri, Delhi	MBT	1-Jul-2009	Delhi	175	82%
8	2,867	Installation of Bundled Composting Project in the state of Tamil Nadu	MBT	2009-2012	Tamil Nadu	40	41%
9	3,248	Bundled Waste Processing Facilities in India	MBT	NA[12]	Punjab & Kerala & Karnataka	1300	46%
10	5,642	Kollam Solid Waste Composting Project	MBT	1-Mar-2012	Kerala	NA	NA
11	NA[13]	6.6 MW MSW to Electricity Generation Project	RDF for electricity generation	1-Nov-2003	Andhra Pradesh	1300	
12	NA	50 TPD Biomethanation plant using MSW at Timarpur, Delhi by Timarpur Waste Management Company Pvt Ltd	RDF for electricity generation	27-Jan-2012	Haryana	500	

The total capacity of all MSW projects including those registered (according to their PDDs) from CDM pipeline could cover about 37 kilo tons per day of MSW which would be about 26% of total MSW generated in India currently. But the actually treated amount is much lower due to the fact that only a small portion of the projects are commissioned, and those usually do not run at full capacity. The actual amount of MSW treated in CDM registered and commissioned plants is only 1337 tPD as per the monitoring reports of seven CDM projects with successful issuance. For the present study, it has been assumed that the actual treated capacity of issuing projects has remained same over the years as per their last issuance.

The key technology choices or mix of technology choices made by project developers in MSW management CDM projects are Biomethanation, Refuse Derived Fuel (RDF) for industrial use,

12 Since CERs have been issued and hence it has considered that this project is commissioned in the absence of commissioning date in the monitoring report.
13 CDM activity stopped whether or not project is operational.

RDF for electricity generation, Mechanical Biological Treatment[14] (MBT), MBT + RDF for industrial use, MBT + RDF for electricity generation, MBT+ Biomethanation, Landfill with gas recovery for energy use and Recycling + Biomethanation + Vermi composting + MBT.

However, the issuing projects are only MBT projects (6) and one RDF generating project. Among the registered but not issuing projects, there are two landfill gas projects. Given that this project type is very common in other countries, it needs to be analysed whether there are specific barriers for landfill gas projects in India.

Projects from the CDM pipeline as highlighted in Table 33 show that the MBT and power generation from RDF are the most preferred technology choices at all stages of CDM projects, including pipeline. A further analysis shows that MBT has been preferred option for treatment of small quantity of MSW (less than 500 TPD) whereas RDF or a combination of MBT and RDF are preferred option for treatment of larger quantity of MSW (above 500 TPD of waste). The same analogy can be drawn from operational projects with issued CERs.

Table 33: Technology choices of MSW projects in CDM pipeline

Sl No	Technology choice	Registered projects with issuance			Registered projects without issuance		Projects under validation		Validation terminated/ withdrawn		Projects in CDM pipeline	
		Number	MSW-Esti-mated (TPD)	MSW-Actual (TPD)	Number	MSW (TPD)	Number	MSW (TPD)	Number	MSW (TPD)	Number	MSW (TPD)
1	Bio-methanation						1	1,300	3	950	4	2,250
2	RDF for industrial use				1	500			2	600	3	1,100
3	RDF for electricity generation	1	505	211	4	5,255	1	700	8	6,788	13	12,743
4	MBT	6	1,867	1,126	10	3,357	2	500	5	3,050	17	6,907
5	MBT+RDF for industrial use				2	780	7	3,920	6	3,980	15	8,680
6	MBT+RDF for electricity generation						1	1,262			1	1,262
7	MBT+ bio-methanation								2	1,400	2	1,400
8	Landfill with gas recovery for energy use				2	1,200			1	1,500	3	2,700
9	Recycling + bio-methanation + vermi composting +MBT								1	NA	1	NA
	Total	7	2,372	1,337	19	11,092	12	7,682	28	18,268	59	37,042

14 Note that the category "MBT projects" in most cases includes, or is exclusively, composting activities which in India in many cases refers to aerobic biological treatment of non-segregated MSW with compost as a product. According to international terminology, composting refers to aerobic biological treatment of pure (segregated) organic waste streams with the aim of producing compost, while MBT is a process similar to composting, but for treating mixed MSW streams with the main objective to reduce waste quantity, reduce its methane and leachate generation and in some cases produce RDF.

Figure 20: Share of treated MSW quantities by projects in CDM pipeline

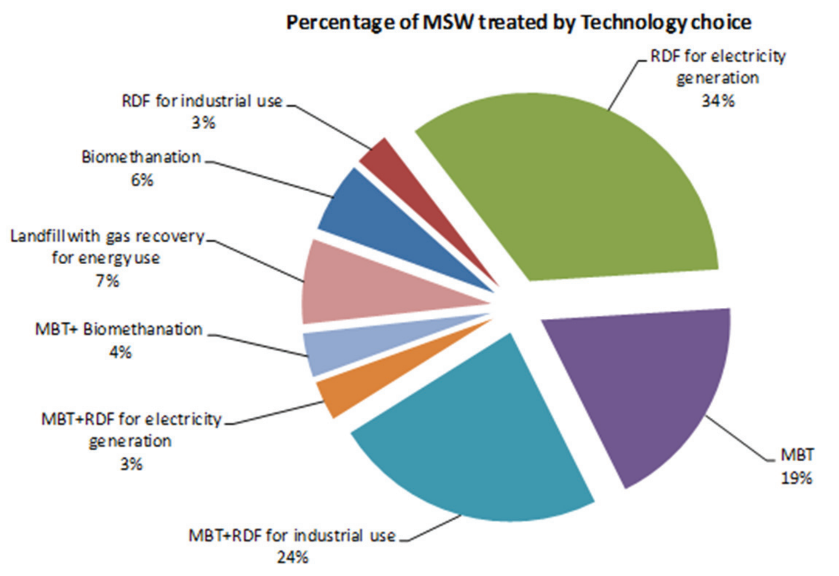
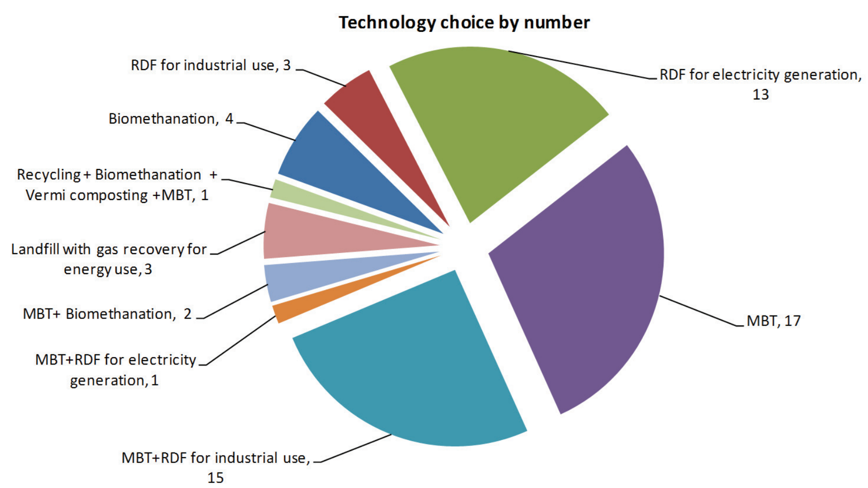


Figure 21: Share of technology choices for projects in CDM pipeline



The key project developers in CDM projects in MSWM sector in India are A2Z Infra, Hanjer Biotech, IL&FS, Terra Firma and SPML Infra[15] (Table 34). From the issuance success point of view, IL&FS has got issuance from 3 of its projects.

Table 34: Key players in CDM projects in MSW sector

Key players	Total	Registered	Under validation	CDM terminated	CERs issued
A2Z Infra	7		7		
Hanjer Biotech Energies (P) Ltd.	7			7	
IL&FS	6	6			3
Terra Firma	5			5	
SPML Infra Limited	5	2	1	2	
Others	30	11	4	15	4
Total	60	19	12	29	7

15 Company or their subsidiary

Table 35: List of technology choices considered by key players for CDM MSW projects

Key players	Technology choices adopted by key players
A2Z Infra	7 (MBT+RDF for industrial use)
Hanjer Biotech Energies (P) Ltd.	5 (MBT+RDF for industrial use) 2 (RDF for industrial use)
IL&FS	4 (MBT) 1 (RDF for electricity generation) 1 (landfill with gas recovery for energy use)
Terra Firma	2 (MBT+ biomethanation) 1 (MBT) 1 (landfill with gas recovery for energy use) 1 (biomethanation)
SPML Infra Limited	3 (MBT), 2 (MBT+RDF for industrial use)
Others	30

4.2.3 Key findings from CDM projects in the solid waste sector

CDM is the first and by far the largest carbon offset market based mechanism which managed to attract climate finance to India. Having 59 projects from MSW in CDM pipeline (with 19 projects registered in MSW sector) of the total 1,544 registered projects, India holds rich experience in CDM.

The most common mitigation options are MBT, Biomethanation, RDF for electricity generation, RDF for industrial use, and landfill gas recovery. The share of registered and issuing projects show that there are apparently favourable conditions for MBT projects (which includes composting of organic material), and to a lesser degree RDF production. On the other side, landfill gas related registered projects are only 2 but they are not issuing, and biomethanisation has not even registered projects. Issuance success varies massively between projects. There are several private sector companies which are active in the solid waste management sector in India with CDM related projects – Hanjer Biotech, A2Z Infra, SPML, IL&FS, Terra Firma. These companies also have experience towards managing waste sector projects from mitigation point of view.

4.3 KEY BARRIERS AND CHALLENGES TO SWM IN INDIA

Key barriers and challenges for improving the MSW sector in India are identified based on a review of waste sector policies and programmes inter alia other secondary sources. Inferences from CDM experience in the waste sector in India have also been taken into consideration. In addition, conjectures about challenges and barriers in the SWM sector have been derived from the meetings with a number of stakeholders (ranging from government agencies/departments/ministries to private institutions/developers; NGOs to thinks tanks/academic institutions etc.) during the course of the study.

Following is a summary of key issues and barriers identified which should be targeted by prospective NAMA option(s). The issues and barriers have been categorised as policy and regulatory barriers, technological barriers, economic and financial barriers, institutional and capacity barriers, and other barriers.

4.3.1 Policy and regulatory barriers

Currently MSW management in India is mainly governed by MSW Rules (2000) developed by the Ministry of Environment and Forests. However, it has failed in meeting the goals expected out of it. New revised MSW rules are under draft stage and are expected to be finalised in the current year. The key issues identified related to policy and regulatory aspects in the country are

1. Solid waste management is a state subject and there is lack of state policy or uniformity in policy guidelines amongst various states in the management of MSW.
2. The MSW Rules (2000) state the "prohibition of disposing organic material", however in the far majority of municipalities still huge quantities of organic material, as part of the mixed MSW, are disposed of.
3. Absence of a comprehensive short and long term planning to handle MSW in accordance with the MSW Rules (2000) in municipal authorities. Local bodies have so far not prepared a time-bound action plan to carry out collection, segregation, storage, transportation, processing and disposal of MSW.
4. GHG mitigation has not played a significant role in waste management policies and legislation.
5. Local bodies, particularly where population is less than 500,000, are not in a position to finalise contracts on waste processing and disposal.
6. No guidelines on selection and optimisation of technology corresponding to the quantity of waste generation exist; neither the central nor the state governments support this process, hindering ULBs in taking decisions about appropriate technology to be adopted.
7. Non availability of suitable land for disposal of wastes close to cities and towns has led to unscientific disposal practices in and around towns and cities causing breeding grounds for many infectious agents causing diseases like cholera, dysentery, jaundice, typhoid and diarrhoea. Also, distant disposal sites result in high transport cost of waste.
8. Stringent interstate policy on transfer of waste hinders the process of waste available as Alternative Fuel and Raw material (AFR) in one State for RDF production and co-processing in cement plants in another State.

4.3.2 Technological barriers

Technology guidelines are provided in MSW manual developed by CPHEEO under MoUD. This manual is under revision. The revised draft has included incineration as broad term for all waste-to-energy mitigation options. The new MSW manual is expected to be finalised in the current year. The key issues associated with technology are:

1. There is low know-how at all levels and limited research and development to explore and evaluate new, promising SWM technologies.
2. Waste-to-energy requires high investments, sophisticated technology and operational know-how which for some of the WTE presently is not sufficiently available in India.
3. There is little history of successful operation of WTE projects in India. Many currently installed processing plants are non-operational.
4. The successful implementation of a technology option depends on the right input material. It is a challenge to secure the desired quantity and quality of waste for processing in the plant, e.g. for RDF plants.
5. Current, mostly unscientific landfilling practices are unfavourable for optimised landfill gas capture, resulting in a limited number of large disposal sites with a high quantity of historically accumulated organic material. These sites might offer a significant landfill gas generation and are worth to be analysed in further SWM NAMA development.

4.3.3 Economic and financial barriers

Financial support is an imperative prerequisite required for accomplishment of the activities related to development of the solid waste infrastructure and services. In order to give a thrust to MSW management in cities, GoI has endorsed the 12th and 13th Finance Commission Grants. Funds were also allocated for enhancement of MSWM under flagship projects like JNNURM-I, UIDSSMT from 2005 onwards. In addition, funds for MSWM projects are also available from State Government. However, the support provided is inadequate or inefficient. The key challenges highlighted are

1. Lack of funds for waste management with urban local bodies (ULBs).
2. Non existing or incomplete collection of waste management fees, combined with inadequate fee level, from the population and other waste generators.
3. Lack of financial viability of SWM projects due to high capital and operational costs, high cost of debt and low returns.
4. No segregated waste delivered for processing, making the operations difficult and very expensive as a large part of capital requirement goes into setting segregation unit in the facility.
5. Low (or not existing) tipping fees for MSW (per ton) received at the disposal sites.
6. Unavailability of markets for sale of compost and RDF.
7. High risk perception of waste management projects, particularly by private sector investors.

4.3.4 Institutional and capacity barriers

There is an urgent need to train and enhance the capacities of staff involved in solid waste management activities. Formalising the solid waste sector will not only build the capacities of workers to execute more effectively and competently in the existing conditions, but will also instill a sense of responsibility and pride towards their profession. However, some of the issues which need to be dealt with in order to lead to an enhancement in service delivery and hence better management of activities are listed below.

1. Lack of skill sets to set up and manage waste processing and disposal facilities, with the majority of the municipal authorities.
2. Lack of adequately qualified staff in ULBs for handling specific responsibilities for MSW management, and lack of appropriate training programmes for ULB staff.
3. There are limited agencies which can assist local bodies technically, either at state or national level, to prepare waste management plans and implement SWM activities and technologies. Further, a detailed assessment does not exist as to how ULBs would meet targets as per MSW Rules including financial requirements. Preparation of Detailed Project Report (DPR) with estimated fund requirement have not been initiated or completed.
4. No defined role for and limited cooperation between stakeholders including local authorities, individual households, NGOs, industries, R&D institutions, and the government.
5. Institutional mechanism for technology transfer not in place.
6. Lack of capacity and experience in public as well as in private sector in operating efficiently and successful SWM plants (MBT, composting, biomethanisation, WTE, sanitary landfills etc.).
7. Limited awareness and knowledge about low emission SWM technologies and about GHG mitigation on all levels (central, state and local governments). Discussions on SWM usually circle around general improvements and benefits of SWM, and hardly cover GHG mitigation potentials in SWM.

4.3.5 Other barriers

Promoting material exchange and reuse programmes as well as recycling and composting programmes etc. that divert materials from the waste stream which will eventually go to the disposal sites could be very useful in terms of waste reduction and integrating informal sector in this process. The informal sector ("kabadi system / scrap dealers" and rag pickers) plays an important role in the SWM value chain by recovering valuable materials from waste. However, challenges are being faced in this process.

1. Fear amongst municipal staff/private sweepers/ rag-pickers of losing their job/ livelihood if private developers take over waste management.
2. Insufficient reliable data on availability and quantities of wastes, their characteristics, distribution, accessibility, current practices of utilization and/or disposal technologies and their economic viability.
3. There is no periodic and timely dissemination of information of the MSWM activities at all levels which if happens could bring significant behavioural changes.
4. Awareness amongst the states and ULBs about the benefits of integration of various technologies for MSW processing is lacking.
5. Indifference of citizens towards waste management due to lack of awareness. Public outcry against the location of a plant [Not in my backyard (NIMBY) Syndrome]. Lack of awareness on the necessity and benefits of waste segregation.
6. Studies or guidelines outlining comprehensive planning for adequate MSW landfilling by smaller local bodies (for example: ULB generating waste <100 TPD) are not available.
7. Limited awareness about low emission SWM technologies and GHG mitigation in SWM among stakeholders (population, NGOs, private sector).

4.4 REVIEW OF GLOBAL NAMAS IN THE SOLID WASTE SECTOR

As of March 2015, there are 145 NAMAs and 29 feasibility studies in 41 countries in different stages of development in the NAMA database (Ecofys 2015). An analysis of the NAMAs submitted in the waste sector (for details see Appendices 11-13 and UNFCCC (2015b), Ecofys (2015) and UNEP DTU (2015b)) shows that so far 27 NAMAs in 18 countries have been developed or are in development in this sector, of which 13 are submitted to UNFCCC and the remaining 14 are in pre-feasibility stage of their development.

4.4.1 Key findings from NAMAs submitted to UNFCCC in the waste sector

The following has been observed for the solid waste sector NAMAs submitted to UNFCCC: Out of 13 NAMAs submitted to UNFCCC, four seek support for implementation and nine seek support for preparation. As observed from the submitted data to UNFCCC (2015b), most of the parties have envisaged starting the implementation of their proposed NAMAs by 2012/2013. No updated information is available on their implementation though. Key aspects can be summarised as follows

1. **Duration of requested support:** The duration of NAMA support has been envisioned from 1 year to 10 years. The duration is longer for NAMA seeking support for implementation.
2. **Type of waste targeted:** It is observed that NAMAs have waste sources varying from MSW (domestic and similar), over agricultural wastes (e.g. livestock or other biomass wastes) to industrial wastes or waste from the service sector (e.g. from hotels).

3. **Financial support:** Financial support is an imperative prerequisite requested by almost all the parties for accomplishment of their project activities.
   - The financial support varies for different kinds of NAMAs. Implementation of a technology NAMA requires more financial support as compared to the policy NAMAs.
   - In addition, financial support also depends on the timeframe required for the completion of the project activity. For example, a NAMA requiring 12 years (as in Chile) would certainly need more finance as compared to a NAMA requiring just a year (as in Mexico) for its execution.
4. **Technology transfer support:** Technology transfer support is requested by 3 out of 13 parties for whom NAMAs have been submitted to UNFCCC.
   - The support is required, for example, for the installation of organic waste management facilities (specifically dry fermentation plants that include indoor treatment, power generation or "waste-to-energy" (WTE) and compost products obtained from the organic treatment process) as in Chile.
   - For accessing appropriate low carbon and climate resilient technologies to support Dominica's continued transformation to the Greenest Economy in the Caribbean region.
   - For setting up of WTE plants as in Pakistan.
5. **Capacity building support:** Capacity building support is an essential component in almost all NAMAs.

4.4.2 Cases of SWM NAMAs relevant for India

Case 1: Recycling Programme NAMA (Colombia)

In order to ensure success of the Solid Waste NAMA, the Colombian government requests the following climate finance assistance (CCAP, 2013):

1. Contribution to NAMA equity fund (at least USD 20 million)
2. Capacity-building support (USD 2.5 million)
3. Project pipeline development support (USD 2.5 million)

The Colombian government considers that a combination of unilateral contributions and actions along with climate finance support will together create an ideal enabling environment for the success of their proposed Solid Waste NAMA.

Table 36: Case-1 of NAMA submitted internationally

NAMA	Outline	Mitigation options	Policy options	Finance options	Capacity building elements
Recycling Program NAMA (Colombia)	Cornerstones of the NAMA are regulatory changes, the promotion of alternative waste treatment technologies, creation of appropriate financial mechanisms, and the integration of informal recyclers into the formal sector (see NAMA database)	Promotion of Mechanical Biological Treatment (MBT) facilities that can process waste diverted away from landfills to produce commodities such as recyclables, compost, and refuse derived fuel (RDF). • Compost made from mixed waste can be used in public parks or for land reclamation. • From a mitigation perspective, composting of organic waste is paramount to achieving meaningful GHG reductions, since organic waste placed in landfills will create methane emissions once it begins decomposition. • RDF can be sold to cement kilns or other industrial consumers to replace fossil fuels which have a dual GHG benefit of reducing landfill emissions and those resulting from combustion of fossil fuels.	Policies and business models are being designed in order to include informal workers in the moderni-sation of the sector, allowing them oppor-tunities to work in the formal economy and increase the standard of their working and living conditions.	Creation of a NAMA Equity Fund, henceforth known as the "Fund", financed through public resources of Colombia and climate finance contributions from donor countries. The Fund will be revolving in nature which is to say that the returns accruing to the Fund from its investments in several MBT facilities will stay within the Fund and will be accessible for deployment to other projects in the pipeline in future.	Capacity-building at the national and sub-national governments could include: • Creation of NAMA specific posts in Colombian Government for three years. • Consultants to support national government in policy & regulatory design, technical standards for alternative technologies and processes and MRV Systems. • Consultants to support municipalities through studies on plans for source separation & selective routes, markets for recyclables, compost and RDF and integration of informal workers.

Case 2: Harnessing Municipal Waste of Big Cities of Pakistan to Generate Electricity (Pakistan)

The NAMA proposed by Government of Pakistan (2015) is designed to attract the private sector to invest in the WTE power projects. It is estimated that through an investment of slightly more than USD 20 million, this NAMA will trigger an investment of USD 3 billion from the private sector till 2020 and this quantum can increase more as time passes and such options are being adopted by the end consumers in different sectors of economy. The government believes that development of WTE power projects will lead towards attaining the goal of sustainable development, self-reliance and self-sufficiency in meeting energy needs of the end consumers and promoting clean sources of energy.

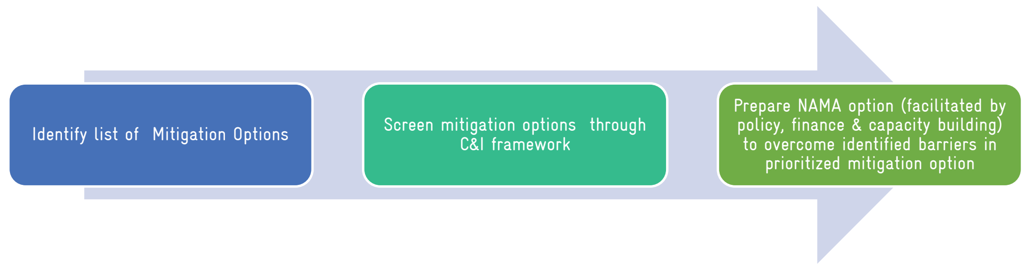
Table 37: Case-2 of NAMA submitted internationally

NAMA	Outline	Mitigation options	Policy options	Finance options	Capacity building elements
Harnessing Municipal Waste of big Cities of Pakistan to Generate Electricity (Pakistan)	Mainstay of this NAMA includes developing regulatory, legislative and financial instrumental streams for the development and promotion of municipal waste management system and deploying them for energy generation (see NAMA pipeline and NAMA database).	Biomass/Waste to Energy (BM / WTE) is envisioned as a reliable technology to deal with waste problem in Pakistan.	Some policies and regulatory would be needed to address waste management issues being faced in the country. However, detailed information is not provided.	The project envisages to result in establishment of a Guarantee Support fund that would be useful in financing the end customers through soft financing schemes for installing waste to energy power plants to cover initial higher capital cost for installing these systems.	Capacity building exercise would be needed at various levels for accomplishing the NAMA. However, detailed information is not provided.

4.5 NAMA OPTIONS TO OVERCOME CHALLENGES AND BARRIERS IN THE SOLID WASTE SECTOR

A NAMA option should be able to overcome the challenges and barriers faced by the sector discussed in Section 4.3. A NAMA option will be a combination of the elements technology (mitigation options), regulatory, policy and financing instruments, supported by capacity building elements which are determined by the ambition level, development needs and readiness of the country (see details in Section 9). The following figure shows Approach 1 for preparation of a NAMA option in SWM sector: Starting from the mitigation option (see Section 9 for detailed description of Approach 1 and Approach 2):

Figure 22: Approach for formulation of NAMA options



A preliminary list of mitigation options is prepared based on our analysis of key policies in waste management in India, past experience of mitigation in waste sector (focus mainly on CDM experience in waste sector), stakeholders' views, and review of NAMAs developed or under development globally in the waste sector. The options are in line with the waste management hierarchy as defined in the Draft MSW Manual (MoUD and CPHEEO, 2014) as shown in Table 38 below, and the C&I defined in Section 3.

Table 38: Waste management hierarchy (MoUD and CPHEEO, 2014)

Tiers	Hierarchy	Order of preference	Description
Tier 0	At Source Reduction & Reuse	Most to least preferred ↓	Waste minimisation and sustainable use/multi use of products (e.g. reuse of carry bags/packaging jars)
Tier 1	Recycling		Processing inorganic waste to recover commercially valuable materials (e.g. Recycling of dry materials)
Tier 2	Composting		Processing organic waste to recover compost (e.g. composting)
Tier 3	Waste to Energy		Recovering energy before final disposal of waste (e.g. Biomethanation, RDF for industrial use, RDF for electricity generation, Co-processing of waste in industry, Plasma gasification)
Tier 4	Landfills		Safe disposal of inert residual waste at sanitary landfills (e.g. MBT, landfill with gas recovery for energy use, landfill with gas recovery with flaring, landfill without gas recovery, unscientific dumping)

Besides mitigation options, regulatory policy instruments, fiscal policy instruments and capacity building elements are listed below based on the insights gained through stakeholder consultations, secondary sources and experience from international NAMAs in the waste sector (see Section 4.4).

Table 39 provides a list of mitigation options, regulatory policy instruments, fiscal policy instruments and capacity building elements from which suitable elements can be picked and combined to result into various NAMA options.

Table 39: Mitigation options, regulatory policy instruments, fiscal policy instruments and capacity building elements for definition of NAMA option

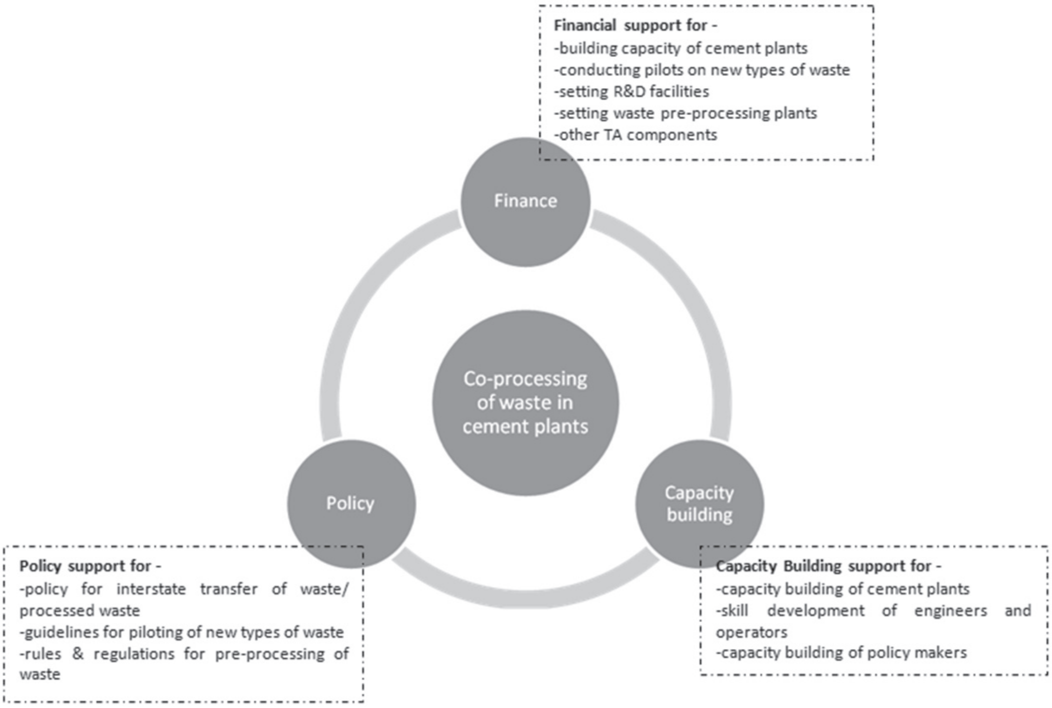
Mitigation options[16]	Regulatory policy instruments	Fiscal policy instruments	Capacity building
1. At source reduction and reuse	**Applicable to all mitigation options:**	**Direct fiscal support[17]:**	**Government sector:**
2. Recycling of dry materials	R1 – Mandatory segregation of waste across value chain	F1 – Output based incentive through tipping fee for municipal waste received (treated)	CB1– Setting up data collection & management system (central monitoring system)
3.1 Aerobic composting	R2 – Single window clearance for waste management projects	F2 – Government-specified price for purchase of recyclable materials/compost, feed-in-tariff for electricity from WTE or LFG projects	CB2 – Research & development facilities for waste technology implementation
3.2 Vermicomposting	R3 – Facilitation of land identification & acquisition	F3 – Viability Gap Fund (VGF)[18]	CB3 - Training & development of government staffs
3.3 Biomethanation	**Specific to mitigation options:**	F4 – Revolving Loan Fund (RLF)[19]	CB4 – Strenghtening of number of staff at CPCB/ SPCBs/ ULBs
4.1 RDF from MSW for co-processing in cement industry	R4 – Facilitation of markets for recyclable materials and for other outputs e.g. compost and RDF	F5 – Tax and tariff exemption on plant & machinery for waste treatment technologies;	CB5 – Institutional capacity building for evaluation & approval of new technology
4.2 RDF for power plant	R5 – Quality standards and label for compost	F6 – Tax incentives for recycled material	**Private sector:**
4.3 RDF for thermal use in industry (other than cement)	R6 – Clear guidelines allowing inter-state transfer of waste in case of co-processing of waste	**Indirect fiscal support[20]:**	CB6 – Capacity building of informal sector
4.4 Incineration plant for mixed MSW with electricity generation	R7 – Guidelines for pre-processing of waste in Industry	F7 – Minimum user fee at household level for waste collection, segregation & transportation	CB7– Outreach/ awareness programmes for citizens
4.5 Gasification, pyrolysis, plasma	R8 – Clear legislative framework and facilitated processing of electricity feed-in WTE or LFG projects	F8 – Access of ULBs to central government infrastructure funds contingent on achievement of SWM benchmarks	
5.1 Mechanical Biological Treatment (MBT)		F9 – Taxes on non-biodegradable consumer products;	
5.2 Active LFG capture with electricity generation		F10 – Reduction of fertiliser subsidies	
5.3 Active LFG capture with flaring			
5.4 Methane oxidation layer			

Example of NAMA option: RDF from MSW for co-processing in cement industry

As an example, RDF from MSW for co-processing in the cement industry may have the following aspects of policy, finance and capacity building elements, as shown in the following figure:

16 The numbering of mitigation options refers to the tier of the waste management hierarchy.
17 Direct fiscal support to private sector for processing of waste using mitigation option(s)
18 A VGF supports projects by providing financial support either in the form a capital subsidy or result based financing for activities like collection, segregation, transportation and treatment of waste
19 A RLF will provide discounted rate loan to waste management projects which meet the criteria of RLF
20 Indirect fiscal support to the waste sector as a whole

Figure 23: Example of a NAMA option: RDF from MSW for co-processing in cement industry



In Section 7, a detailed assessment of each of the above mitigation options is carried out through the set of C&I developed in Section 3.

5 Economic analysis of SWM mitigation options

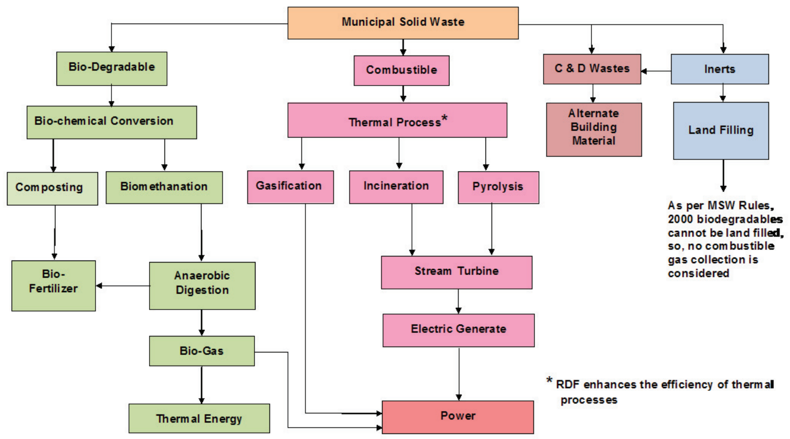
The main objective of this section is to assess the financial costs and benefits from the most relevant GHG mitigation options in the Indian MSW sector, based on the consortium's assessment of conditions in India and international best practices. This analysis will achieve a transparent presentation of available data sources for the purpose of economic analysis.

The analysis will serve as a basis for presenting the economic implications of mitigation options in the form of a tentative Marginal abatemenet cost (MAC) curve in the subsequent Section 6. The economic analysis of costs and benefits should be understood as only one of several assessment approaches including sustainable development criteria as identified in Section 3 and the concrete feasibility of political programmes and projects (as discussed in Section 7).

Most of the technology options obtainable for processing of MSW are based on either bio-conversion or thermal conversion (UNEP, 2005). The bio-conversion process is relevant for the organic fraction of wastes, to form compost or to generate biogas. Various technologies are existing for composting such as aerobic and vermicomposting. Biomethanation (anaerobic digestion) to produce biogas as a renewable energy source is another option. The thermal conversion technologies are incineration with or without heat recovery and electricity generation, pyrolysis and gasification, plasma pyrolysis and pelletisation or production of Refuse Derived Fuel (RDF).

Selecting an adequate set of technologies is essential for the treatment and disposal of municipal solid wastes. The profitable utilisation of fractions of municipal solid wastes can be achieved by employing a combination of technologies suitable for treating various components of wastes. Figure 24 below illustrates options available for municipal solid waste treatment and utilisation (Planning Commission, 2014).

Figure 24: Options for MSW (Planning Commission, 2014)



In India, a multiplicity of technologies is common practice and has further been considered for implementation to manage MSW at various levels of automation and scale. Some technology options focus on mitigation of GHG emissions while others are reducing non-GHG-related environmental impacts.

The following mitigation options will be discussed in this section with regard to their economic implications and the various determinants of their cost. All these options are specific and appropriate to a particular type of waste composition. Some options are applicable to the entire (mixed) waste, others require segregation of waste fractions as their efficiency is reduced in case of treatment of mixed waste streams.

1. At source reduction and reuse
2. Recycling of dry materials
3.1 Aerobic composting
3.2 Vermicomposting
3.3 Biomethanation
4.1 RDF from MSW for co-processing in cement industry
4.2 RDF for power plant
4.3 RDF for thermal use in industry (other than cement)
4.4 Incineration plant for mixed MSW with electricity generation
4.5 Gasification, pyrolysis, plasma
5.1 Mechanical Biological Treatment (MBT)
5.2 Active LFG capture with electricity generation
5.3 Active LFG capture with flaring
5.4 Methane oxidation layer

5.1 ELEMENTS OF COSTS

The typical installation costs and operation and maintenance costs are dependent on the technologies adopted. Costs vary with scale of the treatment site, the extent of automation of treatment processes, geographical location and availability of required extent of land. The land is typically provided by the authorities at nominal lease, but the extent of land along with the lay of land, ground water, contour, accessibility all add to the cost of development of the project.

The capital costs indicated in the following list are for the case of fully separated waste streams where required for the specific mitigation option (e.g. composting) (Planning Commission, 2014). In situations where the information is lacking, field information from working projects and expert judgment has been applied, and thus O&M costs have been derived from DPRs which typically consider mixed waste streams. Due to the mixing of wastes, treatment of biodegradable waste needs to be deployed in conjunction with technologies for treatment of non-biodegradable waste such as plastic pellets, RDF, pelletisation, co-processing and other thermal treatment technologies. The only exception related to the mitigation options under investigation, in which mixed waste is treated without separation of waste streams are mass burn technologies and (historical) landfilling of mixed waste.

Generally, a detailed evaluation of cost and revenues for the different mitigation options would require a site-specific analysis for each option. Such an analysis is not under the scope of this feasibility study. Accordingly, the figures presented are only indicative values.

1. At source reduction and reuse: There are manifold options under this category from reducing the material used for packaging (e.g. material used per bottle) to changing the design of packaging to promote its reusability. Given the various options, various involved players (producers vs. consumers), the capital costs and the O& M costs cannot be specified under the scope of this feasibility study.

2. Recycling of dry materials: In conformance to the 3R principle, recovery of material for recycling is key step in any waste management solution of ULBs. The recovery occurs at various stages – informally at collection stage and secondary transfer stage and formally at the dry waste center wherever implemented. The residual if any after such decentralised recovery is finally extracted at the mixed waste processing plant. In the case of informal recovery, the capital costs are zero while in the case of formal dry waste collection centers (DWCC) or recovery centers, the capital cost varies between INR 2 - 2.5 million per ton per day (TPD) of waste treatment capacity of incoming waste. (Capital costs extrapolated from Bangalore DWCC). The O&M costs are ranging between INR 1,500 - 2,000 per ton of incoming waste.

Figure 25: A typical dry waste collection centre

3.1 Aerobic composting is the most preferred technology and several variations are possible, depending on waste quantities. Box composting, pit composting are used mainly in small towns especially in the North India. For larger plants (>20 tons per day (TPD)) windrow composting technology is practiced. The capital cost varies between INR 0.5 - 1 million/TPD of incoming waste and the O&M cost is INR 400/ton of incoming waste. The key success factors for composting plants are availability of segregated waste and having an assured market for compost at close radius.

3.2 Vermicomposting is adopted exclusively for purely segregated kitchen waste and market waste. Due to the organisms involved, it is sensitive and requires skilled personnel for its operation. The capital cost is INR 0.8 - 1.2 million/TPD of incoming waste and O&M cost is about INR 500/ton of incoming waste. The vermicompost is preferred by farmers in comparison to compost from aerobic process due to the perceived high quality and availability of micronutrients and bioenzymes.

3.3 Biomethanation is adopted exclusively for purely segregated kitchen waste and market waste. It is similarly sensitive and requires skilled technical personnel. The capital costs is INR 1.5 - 2 million/TPD of incoming waste and the O&M cost is about INR 410/ton of incoming waste. The plants are successful in small capacity but larger plants have not yet been proven practical in India due to quality issues with raw waste. The end products are electricity or biogas (methane) and compost. Due to the energetic use of biogas, this option can be seen as a WTE option.

4.1 RDF from MSW for co-processing in cement industry: RDF from MSW for co-processing in cement industry is similar in terms of costs to other RDF plants with capital cost at the MSW plant being close to INR 200,000 - 300,000/TPD of incoming waste and the O&M costs estimated at INR 150/ton of incoming waste. The RDF is provided ex works and therefore the transportation costs are not included. In case of cement plant co-processing, the RDF fraction needs to comply with requirements in terms of size and quality such as calorific value, moisture content, chloride levels. The retrofit cost for setting up a preprocessing plant is about INR 1.5 - 2 million/TPD of incoming combustible waste (INR 200 million/100TPD). A retrofit is needed at the cement plant kiln to incorporate the feeding mechanism for the RDF. The feeding mechanism costs about INR 0.8 - 1.0 million/TPD (INR 80 - 100 million/100TPD). The O&M cost for operating the preprocessing and feeding mechanism is about INR 600 - 800/ton (Reference: Correspondence with representatives from ACC limited and Ecoparadigm).

4.2 RDF for power plants is similar in terms of costs for the RDF plant with capital cost at the MSW plant being close to INR 200,000 - 300,000/TPD of incoming waste and the O&M costs estimated at INR 150/ton of incoming waste. The products are sold ex works and are transported at the cost of the consumer. Therefore the transport costs are excluded in this estimate.

4.3 RDF for thermal use in industry (other than cement): As per the options above, additional costs are roughly INR 200,000 - 300,000/TPD and the O&M cost is about INR 150/ton of incoming waste. The products are sold ex works and are transported at the cost of the consumer. Therefore the transport costs are excluded in this estimate. The typical consumers are currently small kilns who use the RDF as a coal substitute. It is the responsibility of the consumer to comply with the emission norms stipulated by the respective pollution control boards of the State. Currently, there are no separate standards for RDF burning.

4.4 Incineration plant for mixed MSW with electricity generation has not been proven as a treatment approach for mixed waste in the Indian context given that previous pilot projects (Selco, Hyderabad, Vijaywada, Timarpur, and Kanpur have closed due to commercial reasons and quality issues of the incoming waste). Recently there has been a renewed effort to establish WTE projects with two new projects being set up. Their financial viability is yet to be proven. Typical capital costs of such incineration projects are INR 1.6-2.2 million/TPD and the O&M cost is estimated at INR 1000/ton of incoming waste.

4.5 Gasification, pyrolysis, plasma: Typical capital costs of such incineration projects are INR 1.6-2.2 million /TPD and the O&M cost is estimated at INR 1000/ton of incoming waste. These technologies are emerging technologies and there is very limited experience in handling the technology in India and comparable countries for the treatment of MSW. Currently there are no commercial plasma project based on plama technology in the country. These technologies are emerging technologies and there is very limited experience in handling the technology in India and comparable countries for the treatment of MSW. According to a literature survey only two projects are available in the world (Proceedings of the 18^{th} Annual North American Waste-to-Energy Conference 2010). Capital costs of these projects range from INR 13.5-17.8 million/TPD (USD 224,670-296,666/TPD) and the O&M cost is estimated at INR 4877/t (USD 81.3/ton) of incoming waste (Young 2010, Beck 2003).

5.1 Mechanical Biological Treatment (MBT): This is not very prevalent in India although its working is similar to a compost plant. An MBT plant will digest organic waste fractions before landfilling, to ensure minimal emission from the sanitary landfill. In contrast to the composting options above, the entire waste (mixed) is composted with a mechanical pretreatment depending on the specific processes. MBT plants are typically not able to sell the resulting compost to the market due to issues of poor quality and inert waste fractions included in the output of the MBT plant. As a result, the compost from MBT plants is deposited of on the sanitary landfill. Since the infrastructure is similar to compost plant, the capital cost is estimated to be between INR 0.5-1 million/TPD and the O&M cost is estimated to be INR 450/ton of incoming waste.

5.2 Active LFG capture with electricity generation is a technology that has not been applied in India to date. However, the technology is similar to a sanitary landfill with passive ventilation but with additional gas collection equipment, an engine-generator set (genset) and an emergency flare attached. The estimated costs would be INR 550/TPD and O&M cost is INR 125/ton of incoming waste.

5.3 Active LFG capture with flaring is a technology that has not been applied in India to date. However as a technology it is similar to a sanitary landfill with passive ventilation but with additional gas collection equipment and a flare attached. The estimated costs would be INR 530/TPD and O&M cost is INR 80/ton of incoming waste.

5.4 Methane oxidation layer: This is not applied yet as a technology in India. Cover material is introduced to (closed) landfills that results in partial oxidation of methane while the landfill gas passes this cover. The cost would depend very much on the material used as cover material. Compost from compost plants or MBT plants could be used as cover material.

Table 40 gives an overview of capital costs and O&M costs as indicated in the above list.

Table 40: Range of costs per ton of waste for the different technologies offering opportunities for mitigation

No.	Mitigation options	Capital costs *	Operation and maintenance costs**
1	At source reduction and reuse	N/A	N/A
2	Recycling of dry materials	INR 2-2.5 million/TPD (USD 33,333- 41,666/TPD)	INR 1500-2000/ton (USD 25-33/ ton)
3.1	Aerobic composting	INR 0.5-1 million/TPD (USD 8333-16,666/TPD)	INR 400/ ton (USD 6.7/ ton)
3.2	Vermicomposting	INR 0.8-1.2 million/TPD (USD 13,333-20,000/TPD)	INR 500/ ton (USD 8.3/ ton)
3.3	Biomethanation	INR 1.5-2 million/TPD (USD 25,000 – 33,333/TPD)	INR 410/ ton (USD 6.8/ ton)
4.1	RDF for co-processing in cement plants***	At MSW plant: 0.2-0.3 million INR /TPD (USD 3,333 – 5,000/TPD) At cement plant: INR 2.3-3 million/TPD of RDF (USD 38,333 – 50,000/TPD)	At MSW plant: INR 150/ ton (USD 2.5/ ton) At cement plant: INR 600-800/ tont of RDF (USD 10-13.3/ ton)
4.2	RDF for power plants	INR 0.2-0.3 million /TPD (USD 3,333 – 5,000/TPD)	INR 150/ ton (USD 2.5/ ton)
4.3	RDF for thermal use in industry	INR 0.2-0.3 million /TPD (USD 3,333 – 5,000/TPD)	INR 150/ ton (USD 2.5/ ton)
4.4	Incineration of mixed waste for electricity	INR 1.6-2.2 million/TPD (USD 26,666 – 36,666/TPD)	INR 1000/ ton (USD 16.7/ ton)
4.5	Gasification, pyrolysis, plasma, etc.	INR 1.6-2.2 million /TPD (USD 26,666 – 36,666/TPD) INR 13-18 million /TPD (plasma) (USD 224,670 – 296,666/TPD)	INR 1000/ ton (USD 16.7/ ton) INR 4877/ ton (plasma) (USD 81.3/ ton)
5.1	Mechanical biological treatment (MBT)	INR 0.5-1 million/TPD (USD 8,333 – 16,666/TPD)	INR 450/ ton (USD 7.5/ ton)
5.2	Active LFG capture with electricity generation	INR 550/TPD (USD 9.2/TPD)	INR 125/ ton (USD 2.1/ ton)
5.3	Active LFG with flaring	INR 530/TPD (USD 8.8/TPD)	INR 80/ ton (USD 1.3/ ton)
5.4	Methane oxidation layer	N/A	N/A

* Planning Commission (2014), ** Expert estimation based on DPRs., *** Correspondence of ACC Limited with Ecoparadigm

All costs are based on incoming mixed municipal waste unless otherwise mentioned.

5.2 ELEMENTS OF REVENUES

The revenue from operation of the options described above results from two main sources – namely from *tipping fees* or *gate fees* and from the sale of products such as compost, electricity or thermal energy and biogas (methane), as well any other resources generated through recycling. Tipping fee is a charge which municipal authorities are required to pay to a private operator, who undertakes the responsibility of processing the waste aimed at minimising the waste going to the landfills and in the process derive some useful products to meet part of the cost. The tipping fee is meant to bridge the gap between the amount spent by the concessionaire on processing the waste and the income derived from the products. The fees vary geographically, between technologies, and between different levels of purity of waste streams and of course also between different end products. Normally the urban local body tenders the processing and disposal contracts for processing and disposal of solid waste. The technology choice is normally kept open and it is left to the operator to adopt any set of technology. The tipping fee contracted has actually ranged from minimum zero (Rajkot MSW facility) to INR 180-300/ton of incoming waste (Bangalore). The zero tipping fee model plant has been closed.

In the following, the typical prices for the different mitigation options are indicated: The tipping fee indicated below is the prevailing range of fees paid to MSW operators across India. The selling price of product is the price for these products in the Indian market.

Regarding the mitigation options described above, the following revenue streams have been estimated:

1. At source reduction and reuse: Similar to the costs, also the revenues are very different for the various options under this category. Accordingly, under the scope if this feasibility study, no values can be specified.

2. Recycling of dry materials: The formal material recovery facility like the dry waste collection centres receive dry waste from urban local bodies. These waste streams are segregated according to types such as paper, plastics, cardboard, glass, and iron as shown in the following table. Table 41 shows the procurement prices for segregated material and the materials are typically sold at a margin of 15% over costs.

Table 41: Typical procurement price for segregated materials at DWCC

No.	ITEMS	INR/kg	USD/ton
1	White paper	8	133.33
2	Colour paper	2	33.33
3	Carbon box	5	83.33
4	Milk cover	11	183.33
5	News paper	7	116.66
6	Plastic	15	250
7	Pet bottles	18	300
8	Road waste	2	33.33
9	Glass	1	16.66
10	Tetra packs	3	50
11	Iron	7	116.66
12	Tin	40	666.66
13	Mixed waste	27.5	458.33

3.1 Aerobic composting results in revenue from the tipping fee and from sale of compost. The tipping fee is in the range of INR 180-300/ton of incoming waste and the selling price of compost is INR 1,400-2,200/ton. The selling price varies with quality of compost and also distance of the farmland.

3.2 Vermicomposting results in revenue via the tipping fee and sale of compost. The tipping fee is in the range of INR 180-300/ton of incoming waste and the selling price of compost is INR 1,800-4,000/ton. As stated earlier, the benefits of vermicompost is superior to the city compost and hence it commands a better price.

3.3 Biomethanation results in revenue from the tipping fee and sale of enriched methane biogas. The tipping fee is in the range of INR 180-300/ton of incoming waste and the selling price of enriched methane biogas (compressed biogas CBG 99%) is INR 25,000-35,000/ton. The energy content of CBG is comparable to natural gas which is currently priced at INR 38,000/ton in the Indian market.

4.1 RDF from MSW for co-processing in cement industry from a mixed waste processing plant would result in the same tipping fee in the range of INR180-300/ton of incoming mixed waste. The revenue primarily occurs from the sale of the RDF of acceptable calorific value >3500 kCal/kg, which is priced at INR 420/ton (~30% of average coal price of INR 1,400/ton). In case the RDF material is having less calorific value or is not of acceptable standard, then the MSW operator has to pay a tipping fee of INR 1600-2200/ton of such poor quality RDF and supplied to the cement plant.

4.2 RDF for power plants: The revenues from the tipping fee and the sale of RDF is assumed to be in the same range as for the mitigation option 4.1.

4.3 RDF for thermal use in industry (other than cement): The revenues from the tipping fee and the sale of RDF is assumed to be in the same range as for the mitigation option 4.1.

4.4 Incineration plant for mixed MSW with electricity generation results in revenue from the tipping fee as well as from potential sale of thermal energy or electricity. The tipping fee in the range of INR 180-300 is paid per ton of mixed waste received at the processing plant. The selling price of electricity is INR 5/kWh. The sale of heat would require a consumer close to the incineration plant.

4.5 Gasification, pyrolysis, plasma and related technologies results in revenue from the tipping fee as well as from potential sale of thermal energy or electricity. The tipping fee in the range of INR 180-300 is paid per ton of mixed waste received at the processing plant. The selling price of electricity is INR 5/kWh. The sale of heat would require a consumer close to the treatment plant. Plasma technology would provide electricity of around 500 kWh/t waste, so not really relevant revenues. Other by-products (i.e. vitreous slag) could principally be used for manufacturing of tiles and other construction materials.

5.1 Mechanical Biological Treatment (MBT) results in revenues from tipping fees, from reception of waste received at the processing plant. Unlike composting, MBT does not generate compost for sale and therefore no sales related revenue. The tipping fee is in the range of INR 180-300 per ton of incoming mixed waste.

5.2 Active LFG capture with electricity generation is a technology that has not been applied in India to date. The tipping fee would be same as of a sanitary landfill with passive ventilation and is in the range of INR 180-200/ton of waste supplied to the landfill. Electricity generated from captured landfill gas is priced at INR 5/kWh.

5.3 Active LFG capture with flaring is a technology that has not been applied in India to date. The tipping fee would be same as of a sanitary landfill with passive ventilation and is in the range of INR180-200/ton of waste supplied to the landfill. No other revenues would occur as the flaring of landfill gas does not result in a useful energy supply.

5.4 Methane oxidation layer: depending on the material used for the cover of landfills, small revenues in form of a tipping fee might be applicable. Likely, the landfill site operators would have to pay for the material used. Accordingly, no revenue is assumed for this mitigation option.

Table 42: Typical revenues from various MSW processing technologies offering opportunities for mitigation

No.	Mitigation options	Tipping fee*	Product	Revenue**
1	At source reduction and reuse	N/A	N/A	N/A
2	Recycling of dry materials	N/A	Various recyclables	15% of Table 34
3.1	Aerobic composting	INR 180 – 300/t (USD 3 – 5/t)	Compost	INR 1,400 – 2,200/t (USD 23.33 – 33.33/t)
3.2	Vermicomposting	INR 180 – 300/t (USD 3 – 5/t)	Compost	INR 1,800 – 4,000/t (USD 30 – 66.67/t)
3.3	Biomethanation	INR 180 – 300/t (USD 3 – 5/t)	Biogas	INR 25,000 – 35,000/t (USD 416.66 – 583/t)
			Compost (from residuals)	INR 1,400 – 2,200/t (USD 23.33 – 33.33/t)
4.1	RDF from MSW for co-processing in cement industry	At MSW plant: INR 180 – 300/t (USD 3 – 5/t)	RDF good quality RDF poor quality	INR 420/t of RDF (USD 7/t) (payment from cement plant) INR 1,600 – 2,200/t (USD 26.66 – 36.66/t) tipping cost to be paid to cement plant
4.2	RDF for power plants	INR 180 – 300/t (USD 3 – 5/t)	RDF	INR 1,600 – 2,200/t (USD 26.66 – 36.66/t)
4.3	RDF for thermal use in industry (other than cement)	INR 180 – 300/t (USD 3 – 5/t)	RDF	INR 1,600 – 2,200/t (USD 26.66 – 36.66/t)
4.4	Incineration plant for mixed MSW with electricity generation	INR 180 – 300/t (USD 3 – 5/t)	Electricity	INR 5/kWh (USD 0.083/ kWh)
4.5	Gasification, pyrolysis, plasma.	INR 180 – 300/t (USD 3 – 5/t)	Electricity	INR 5/kWh (USD 0.083/ kWh)
5.1	Mechanical Biological Treatment (MBT)	INR 180 – 300/t (USD 3 – 5/t)	N/A	N/A
5.2	Active LFG capture with electricity generation	INR 180 – 200/t (USD 3 – 3.33/t)	Electricity	INR 5/kWh (USD 0.083/ kWh)
5.3	Active LFG capture with flaring	INR 180 – 200/t (USD 3 – 3.33/t)	N/A	N/A
5.4	Methane oxidation layer	N/A	N/A	N/A

*All tipping fees are for raw mixed incoming waste unless otherwise mentioned.** Contracted prices of various projects

5.3 CONCLUSION OF THE ECONOMIC ANALYSIS

From the perspective of current MSW management practice, integrated MSW projects including compost technology, RDF, and sanitary landfills with passive venting for final disposal appears the most preferred option to date. The composting technology is in general the cheapest treatment option available in India. MBT is an alternative that is applicable to mixed waste streams but does not result in a compost that can be sold to the market. However, the outcome of the MBT process could be used as cover material for landfill sites.

The cost-benefit aspect of technology options in terms of mitigation options is the subject of the subsequent Section 6, which – in addition to technology costs and benefits – also considers their respective mitigation potentials in order to present the full picture keeping in mind the overall objective of this prefeasibility study, which is to explore the possibilities of developing a NAMA in the SWM sector.

Marginal abatement cost curve for the SWM sector in India

6

This section presents a preliminary assessment of the cost-effectiveness of different mitigation options. In order to assess how much mitigation can be achieved – in tons of CO_2 equivalents (CO_2 eq) – we add a layer on top of the economic analysis of technology costs and benefits consisting of the respective mitigation potentials. This will result in an economic assessment of the various options to mitigate GHG emissions in the solid waste sector of India – options, which could then be considered as mitigation actions under a NAMA and evaluated with the other criteria developed in Section 3.

Simplified MACC

We utilise a simplified form in presenting the respective mitigation costs per technology in the form of a simple marginal abatement cost curve (MACC). Abatement costs describe the costs for the reduction of one ton of CO_2 emissions – or the equivalent amount of other greenhouse gases – by a certain mitigation activity. For the design of climate policies, abatement costs are important considerations as they provide an indication of cost-effectiveness of mitigation options as well as an indication of their respective emission reduction volume. MACCs are an information-processing, multi-criteria analysis tool, which is to help decision makers reduce complexity and select appropriate mitigation options. Abatement cost estimates are often based on expert opinion, or on model assumptions on the mitigation target, the emissions baseline, discount rates, and future technological options, among others (Castro, 2010: 4).

Any MACC is composed of two dimensions: the horizontal axis represents an ambitious but feasible maximum mitigation potential of annual GHG emission reductions from a specific technology application (in tCO_{2eq}), while the vertical axis represents the marginal abatement cost (in USD/ tCO_2eq). Abatement costs can also be negative if mitigation options are profitable. Abatement options are listed in order of their abatement cost (from low to high), thus placing the measure with the lowest marginal abatement cost to the left and the most expensive ones on the right. The marginal costs considered are the incremental costs incurred with the implementation of the option with respect to the baseline.

According to Castro (2010), abatement costs are the net present value (NPV) of the costs of a mitigation option (investment, operation and maintenance) less potential revenues/savings (e.g. income from electricity or compost sales), divided by the amount of GHG emission reductions expected over the assessed time frame.

$$\text{Abatemen cost} = \frac{\text{NPV costs} - \text{NPV revenues}}{\text{Amount of GHG emission reduction}}$$

The amount of GHG emission reductions equals the difference of emissions that would be achieved by exclusive implementation of each mitigation option compared to the reference case. The marginal abatement costs (i.e. costs minus revenues) are the differential between cost of each mitigation option and the costs of their reference case alternatives. This means e.g. in case of landfill gas capture to calculate the difference of the costs of constructing a landfill equipped with gas capture versus the costs of constructing a landfill without gas capture. As a result, only the additional costs (and revenues) for the capture system are representing the marginal abatement costs.

Though a MACC presents cost-effectiveness of different mitigation options it should not be the only way for prioritising and selection of the appropriate mitigation options, and determination of NAMA options. The assignation of priorities should consider the economic, social and environmental co-benefits for sustainable development of the MSW sector, and the potential opportunities and barriers for individual options, as well as the interrelations between the mitigation options or technologies. In this feasibility study we will apply the criteria defined in Section 3, whereas the results of the economic assessment will contribute to such an assessment done in Section 7.

MACC are to be interpreted carefully, due to a number of shortcomings. It is for instance important to understand the assumptions behind the MACC: the political and economic decisions required for implementation of particular options can be complex (and incur additional political costs due to interaction with interest groups) – the MACC only represent a simple summary of a more sophisticated system. It is also crucial to look beyond the estimated technology costs: while the MACC might indicate negative marginal abatement costs for some technologies, their implementation may face significant, non-monetary barriers (e.g. social, political, economic, environmental, etc.). Such barriers are not accounted for in the MACC. Finally, there can be significant uncertainties behind the assumptions of the MACC, which are sometimes hidden – we aim to state them in the following transparently.

The technology options with relevance for mitigation

All data and assumptions regarding financial costs and benefits of the technologies are the same as discussed in Section 5. Therefore additional assumptions concern largely the mitigation potential of each technology option. We analyse the following options:

Options for the organic waste fraction (food and garden):

3.1 Aerobic composting

3.2 Vermicomposting

3.3 Biomethanation

Options for RDF suitable waste fractions (paper, wood, textile, plastics):

4.1 RDF from MSW for co-processing in cement industry

4.2 RDF for power plants

4.3 RDF for thermal use in industry (other than cement)

Options for mixed waste:

4.4 Incineration plant for mixed MSW with electricity generation

5.1 Mechanical Biological Treatment (MBT)

5.2 Active LFG capture with electricity generation

5.3 Active LFG capture with flaring

The following options are not included in the MAC curves as they cannot be specified at the level of detail required for the evaluation:

1. At source reduction and reuse
2. Recycling of dry materials

5.4 Methane oxidation layer

Furthermore, the following option is not included as it is not assumed to have shown proof of applicability in India and comparable countries:

4.5 Gasification, pyrolysis, plasma

Waste quantities assessed

The assessment focuses on urban centres of more than 100,000 inhabitants. Beyond the distinction of urban centres, we do not consider regional differentiations with regard to waste composition and technological appropriateness. Limitations of capacity for particular technologies are taken into consideration based on expert judgment. Accordingly, it is assumed that not all options are applicable in cities of less than 100,000 inhabitants.

Currently and in the baseline, not all the waste generated is collected. Given that significant methane generation only occurs in cases of landfills the analysis of mitigation potentials is limited to the waste streams available for treatment. The collection rate for the city groups included in this analysis ranges from 60 to 80%.

In line with the baseline described in Section 2 we apply the annual waste volumes for different types of waste in the IPCC waste model. The volumes of the year 2015 have been used as basis for the estimation of the mitigation potential.

The share of waste treated by the different options has been selected to represent a realistic share of these waste streams, which could be treated by each particular technology. At the same time we ensure that e.g. the mitigation potentials of particular streams are not counted twice and for this distinguish the mutually exclusive categories "biodegradable" (food and garden waste) and "non-biodegradable waste".

Generally, the weighted average share of the waste fractions is differentiated among the city groups with "above 100,000" to "above 5 million" inhabitants.

General assumptions on physical and chemical parameters

Physical and chemical parameters are the same ones as in the baseline (Section 2) and the IPCC FOD method (the IPCC waste model) is used with default data where specific data is missing.

Modeling of methane avoidance by the IPCC waste model

The baseline for the MSW sector has been calculated with the IPCC waste model (IPCC, 2006), differentiated into municipalities of a size of

- 0.1 to 0.5 million inhabitants;
- 0.5 to 1.0 million inhabitants;
- 1.0 to 5.0 million inhabitants;
- above 5 million inhabitants.

In order not to overestimate the mitigation potential from methane avoidance and to achieve comparability to the baseline, the IPCC waste model has been applied to calculate the methane avoidance potential for the period until 2030.

The calculation of the methane potential has been done for the two categories of urban centres of 1 to 5 million and above 5 million inhabitants. For simplification and based on a conservative approach, the category with less emission potential has been used for the MAC curve calculations. The same waste composition and the same MCF distribution as in the baseline have been applied.

Timing of methane avoidance

The development of the MACC is related to a specific time period. In this report, the period until 2030 is selected as scope of the analysis. The methane that is generated from waste disposal however is also time-dependent as shown in Figure 26. This temporal dimension is accounted for by the IPCC waste model.

Figure 26: Methane emissions from 1 ton of waste landfilled in year 0

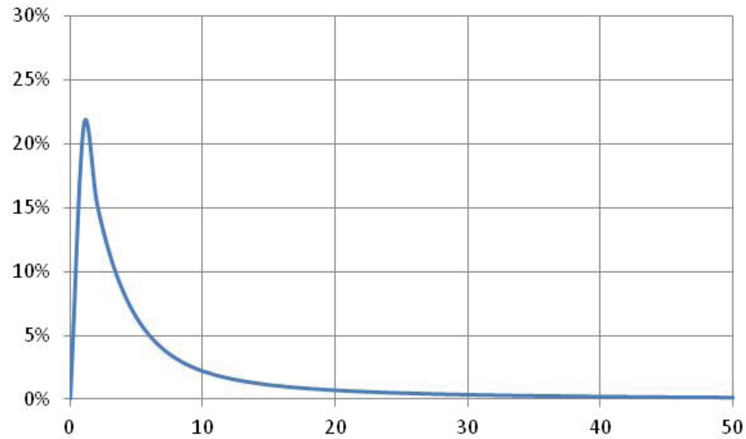
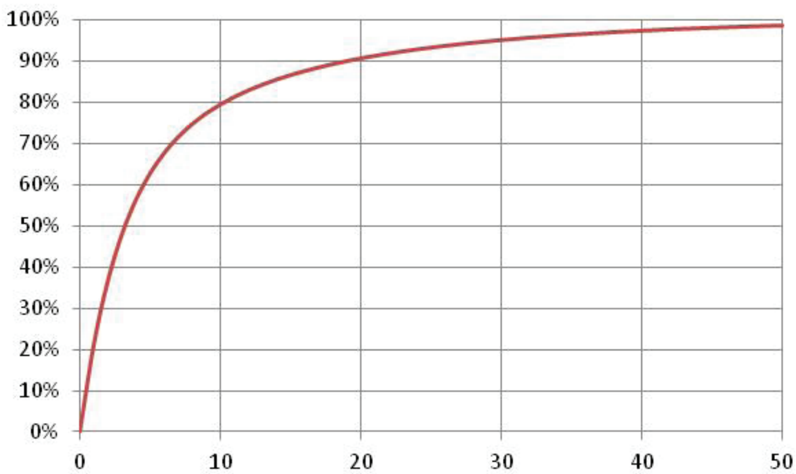


Figure 27: Cumulated methane emissions from 1 ton of waste landfilled in year 0



A ton of waste treated with zero-GHG technology in 2015 would thus result approximately in an emission reduction of 85% by 2030 compared to the overall methane emission potential of the waste, while a ton of waste treated in the year 2030 would not result in net emission reductions in the year 2030. The determination of the mitigation potential due to avoidance of methane generation in landfills therefore considers only emissions reductions occurring within the timeframe of the NAMA – emissions reductions, which are expected to occur at a later stage, would thus be seen as long-term benefits of the NAMA and not necessarily be accounted for under emissions reductions of the NAMA itself.

General assumptions on cost-benefit parameters

The assessment looks at capital cost, operation and maintenance (O&M) cost, revenues, plant lifetime and other input parameters for various mitigation options (see Section 5 for details).

The potential of mitigation considered in the calculations of the used model applies an atmospheric warming potential of 25 for methane (CH_4) (IPCC, 2007) compared to carbon dioxide (CO_2), following the IPCC guidelines with a temporal horizon of 100 years. If one was using the atmospheric warming potential over a temporal horizon of 20 years significantly higher mitigation potentials would be the result. The opposite would be true, however, for nitrous oxide (N_2O), yielding a slightly smaller mitigation effect compared to CO_2 over a time horizon of 20 years (289) than over 100 years (298).

In the following the assumed MSW flows for each mitigation options are presented. For the sake of consistency between the mitigation options, all options are assumed to be implemented in 2015 and operated from 2015 – 2030. Assumptions relevant for calculating the costs and potential revenues of waste treatment in the baseline were taken in Section 5.

Specific assumptions on financial parameters, waste volumes and mitigation potentials

3.1 Aerobic composting

- Quantity of waste (food and garden) that can be treated: 10% of the waste volumes (food and garden) in 2015: approx. 1.8 million tons per year
- Project emissions as per table 4.1 of IPCC 2006
- Sale of compost (50% mass reduction)

3.2 Vermicomposting

- Quantity of waste (food and garden) that can be treated: 2% of the waste volumes (food and garden) in 2015: approx. 0.36 million tons per year
- Project emissions as per table 4.1 of IPCC 2006
- Sale of compost (50% mass reduction)

3.3 Biomethanation

- Quantity of waste (food and garden) that can be treated: 5% of the waste volumes (food and garden) in 2015: approx. 0.9 million tons per year
- Project emissions as per table 4.1 of IPCC 2006
- Biogas production: 50% of total methane potential of waste
- Sale of compost from sludge (50% mass reduction)

4.1 RDF from MSW for co-processing in cement industry

- Quantity of waste (paper, wood, textile, plastics) that can be treated: 50% of the waste volumes (paper, wood, textile, plastics) in 2015: approx. 3.3 million tons per year
- RDF is used for replacement of coal with an effective emission reduction of only 50% on an energy basis (to account for fossil carbon in RDF)
- Investment, operational costs and revenues occur at the MSW plant and the cement plants and are furthermore dependent on the quality of RDF produced. For simplification it has been assumed that only the costs and revenues (i.e. tipping fees) at the MSW plant are taken into consideration for the MACC assuming that the cement plants will not pay

a fee to the MSW plant for the RDF but will undertake the retrofit and operation of the feeding system at the cement plant at their own costs.

4.2 RDF for power plants

- Quantity of waste (paper, wood, textile, plastics) that can be treated: 20% of the waste volumes (paper, wood, textile, plastics) in 2015: approx. 1.3 million tons per year
- Grid emission factor: 750 g CO2 eq/kWh

4.3 RDF from MSW for co-processing in industry (other than cement)

- Quantity of waste (paper, wood, textile, plastics) that can be treated: 10% of the waste volumes (paper, wood, textile, plastics) in 2015: approx. 0.67 million tons per year
- RDF is used for replacement of coal with an effective emission reduction of only 50% on an energy basis (to account for fossil carbon in RDF)

4.4 Incineration plant for mixed MSW with electricity generation

- Quantity of waste (mixed waste) that can be treated: 10% of the waste volumes (mixed waste) in 2015: approx. 2.5 million tons per year
- Grid emission factor: 750 g CO2eq/kWh

5.1 Mechanical Biological Treatment (MBT)

- Quantity of waste (mixed waste) that can be treated: 10% of the waste volumes (mixed waste) in 2015: approx. 2.500 million tons per year
- Quality of composted waste is unlikely sufficient to generate revenues

5.2 Active LFG capture with electricity generation

- Quantity of waste (mixed waste) that can be treated: 7% of the waste volumes (mixed waste) in 2015: approx. 1.7 million tons per year (installed capacity of 20 MWel)
- LFG collection efficiency: 75%
- Grid emission factor: 750 g CO2 eq/kWh

5.3 Active LFG capture with flaring

- Quantity of waste (mixed waste) that can be treated: 10% of the waste volumes (mixed waste) in 2015: approx. 2.5 million tons per year
- LFG collection efficiency: 50%
- Flaring efficiency: 90%

Aggregated attribution of waste streams to particular mitigation options

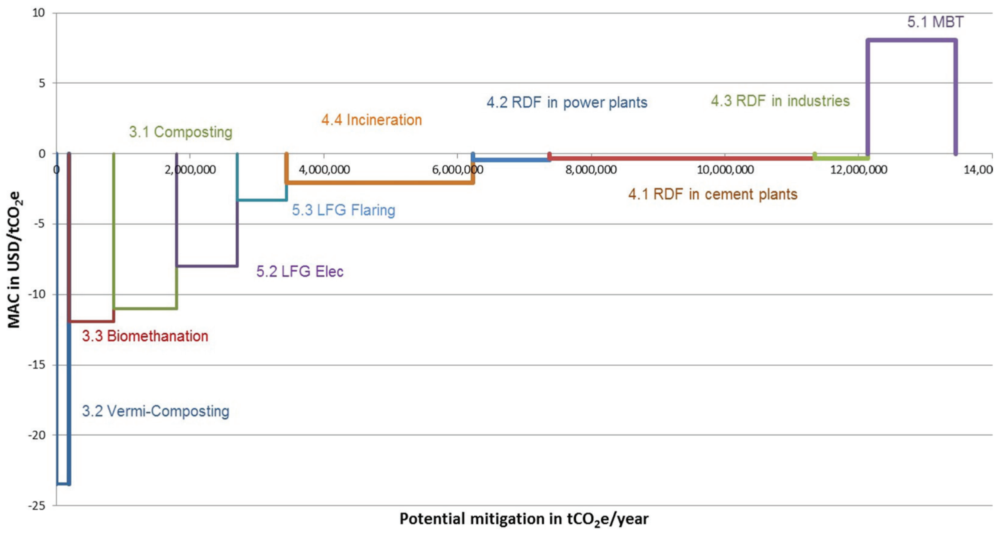
The sum of individual shares of waste going into particular treatments (see above) does not equal the total quantity of waste available for treatment, but reflects a bottom-up assessment of each technology‘s contribution in the relatively short term.

6.1 HIGH COST – HIGH REVENUE SCENARIO

The following graph indicates mitigation potentials and net costs for mitigation options in the Indian solid waste sector as a MACC under a scenario of high costs (using the upper ends of the cost spectrum for each treatment type) and high revenues (using the upper ends of the revenue spectrum for each option).

Independently of these factors which are determined by the cost structure of treatment types, judgment of the aggregate potential for action under a NAMA would then depend on the willingness to finance domestically as well as the availability of international financing to support implementation of more costly and ambitious mitigation measures (going towards the right hand side of the MAC curve).

Figure 28: Draft marginal abatement cost curve under scenario of high waste treatment costs and high waste treatment revenue for mitigation options in the Indian solid waste sector

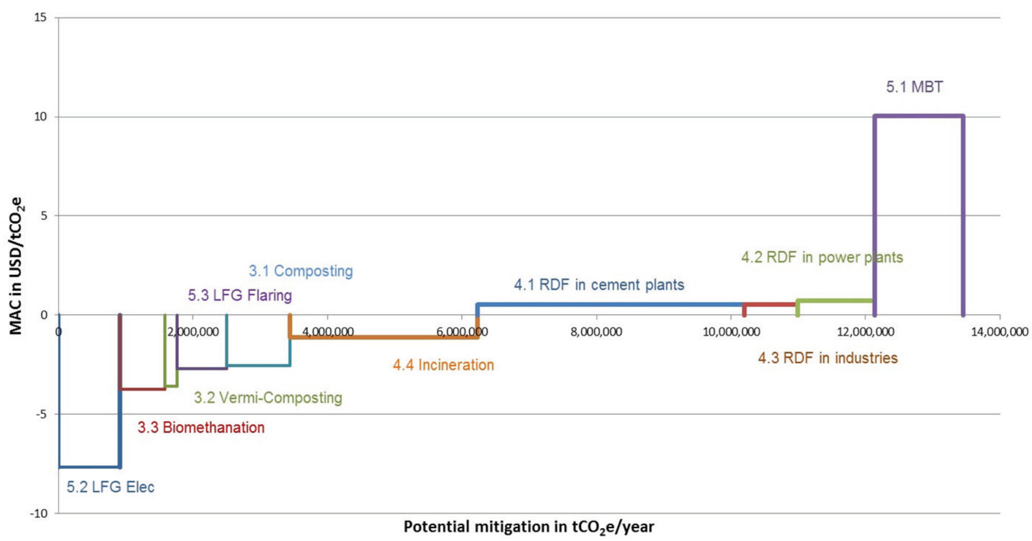


Under a situation of high costs and high revenues, the vermicomposting option is the most attractive measure. Revenues from tipping fees and sales of high quality compost result in significant negative abatement costs. The MBT option with no revenue stream besides tipping fees results in highest abatement costs.

6.2 HIGH COST – LOW REVENUE SCENARIO

The following graph indicates mitigation potentials and net costs for mitigation options in the Indian solid waste sector as a marginal abatement cost curve under a scenario of high costs (using the upper ends of the cost spectrum for each treatment type) and low revenues (using the lower ends of the revenue spectrum for each option).

Figure 29: Draft marginal abatement cost curve under a scenario of high waste treatment costs and low waste treatment revenue for mitigation options in the Indian solid waste sector

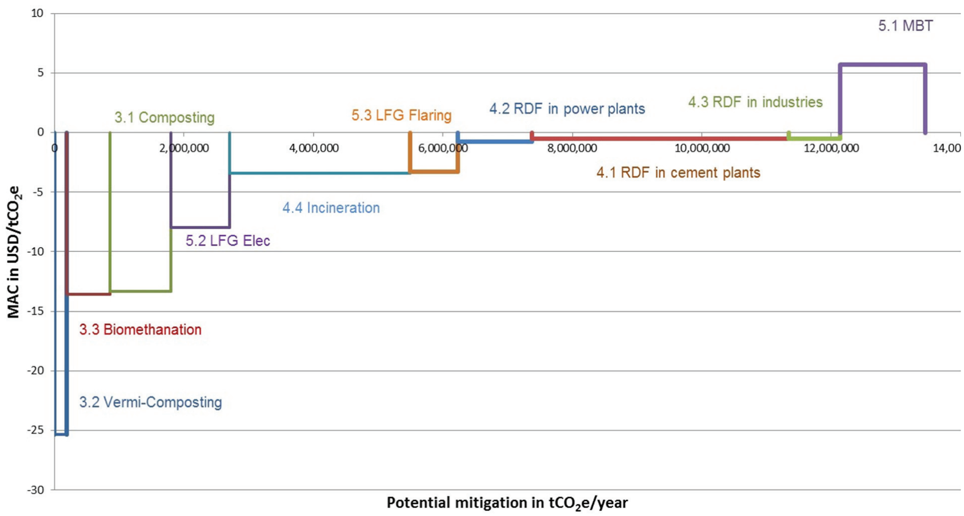


Under a situation of high costs and low revenues, the LFG capture with electricity generation is the most attractive measure. Revenues from tipping fees at the landfill and electricity sales result in negative abatement costs. The MBT option with no revenue stream besides tipping fees results in highest abatement costs.

6.3 LOW COST – HIGH REVENUE SCENARIO

The following graph indicates mitigation potentials and net costs for mitigation options in the Indian solid waste sector as a marginal abatement cost curve under a scenario of low waste treatment costs (using the lower ends of the cost spectrum) and high revenues from treatment. Under this economically beneficial scenario, political leeway to implement also more costly measures may be greater, allowing for development of a more ambitious NAMA.

Figure 30: Draft marginal abatement cost curve under a scenario of high waste treatment costs and low waste treatment revenue for mitigation options in the Indian solid waste sector



Under a situation of low costs and high revenues, the vermicomposting option is the most attractive measure. Revenues from tipping fees and sales of high quality compost result in significant negative abatement costs. The MBT option with no revenue stream besides tipping fees results in highest abatement costs.

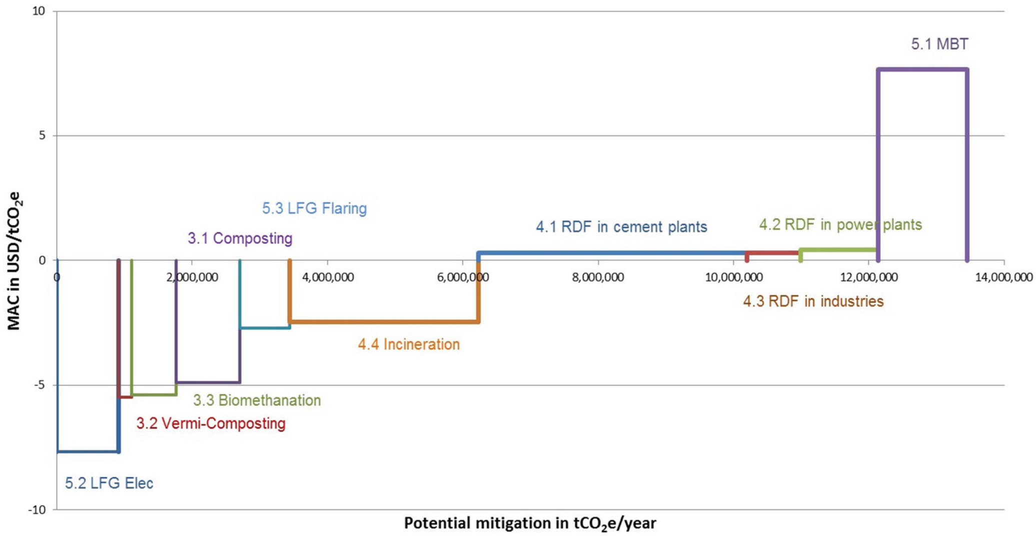
6.4 LOW COST – LOW REVENUE SCENARIO

The following graph indicates mitigation potentials and net costs for mitigation options in the Indian solid waste sector as a marginal abatement cost curve under a scenario of low waste treatment costs (using the lower ends of the cost spectrum) and low revenues from treatment.

Under a situation of high costs and low revenues, the LFG capture with electricity generation is the most attractive measure. Revenues from tipping fees at the landfill and electricity sales result in negative abatement costs. The MBT option with no revenue stream besides tipping fees results in highest abatement costs.

Under all scenarios, the composting options result in negative abatement costs. The RDF options, with the highest overall mitigation potential result in slightly negative or positive abatement costs depending on the different scenarios. The MBT option is linked to highest abatement costs under all scenarios.

Figure 31: Draft marginal abatement cost curve under a scenario of low waste treatment costs and low waste treatment revenue for mitigation options in the Indian solid waste sector



Figures 28-31 illustrate indicatively the mitigation potentials and the respective abatement costs of GHG emissions of the analysed mitigation options, indicating the most attractive measures from the cost-efficiency point of view of the mitigation. It is important to note that in case one specific technology option is selected and its application is to be maximised, its mitigation potential would be greater than indicated above, given that the potentials indicated in a MACC do not represent the maximum potential for each one: its projection is based on conservative assumptions applied by the team of consultants.

In terms of costs and benefits, results do not consider social and environmental co-benefits, which are difficult or even impossible to price. Such considerations are only part of the evaluation done in Section 7. Also synergies with other measures (for example the promotion of renewable energies or management of other types of waste) and consideration of stakeholders‘ interests are not included in this purely technical assessment.

Additionally – going forward in preparing a full MACC assessment in the next phase of NAMA development – a more refined approach should be taken in considering geographical variations relevant for the distribution of mitigation options, as well as a broadening of the underlying data base:

- There are centralised measures that require a minimum concentration of inhabitants and or certain types of waste in order to be economically viable; sanitary landfills with gas capture are likely to be such a case, which probably requires both a sufficient concentration of inhabitants as well as sufficient amounts of organic waste.
- Other technologies can work economically on small scales in decentralized circumstances, such as composting plants.
- Cost estimations, as well as revenues, should be based on investigation of a greater number of plants and with processing of primary data, which was not possible within the Feasibility Study.
- Mitigation options and cost data in smaller municipalities (e.g. 20,000 to 100,000 inhabitants) should be integrated, if available.
- Assumptions regarding waste flows subject to individual mitigation options should be further fine-tuned, based on deeper investigation of current waste flows and current plant sizes (composting, WTE, disposal sites etc.), as well as on interaction with stakeholders and their estimation on realistic waste quantities to be treated.

7 Assessment of mitigation options and policies according to criteria and indicators

In this Section, the mitigation options and policies identified in Section 4 are run through the criteria and indicators framework developed as part of Section 3. The two-step approach of evaluation prepares the subsequent prioritisation of the mitigation options in Section 7.4. Section 7.3 evaluates how ready the institutions are at all levels (Central, State, ULB and Private level). The prioritised mitigation options obtained from this section feed into subsequent Sections (Section 8 and Section 9) for design of a NAMA in the sector. The policy instruments are evaluated to check their effectiveness in driving the mitigation options.

7.1 EVALUATION OF MITIGATION OPTIONS

As indicated in Section 3, all the mitigation options listed under Section 4 are run through two filters for screening & prioritisation. The **1st filter** ensures that the mitigation option is aligned with the existing national and sectoral policies and development priorities. Each mitigation option is checked regarding its consistency with these policies mainly to avoid any conflict. If there is a positive response, only then the further level of check is applied to determine the contribution to sustainable development of the proposed option. In the **2nd filter** a list of suitable and appropriate mitigation options is mapped as per the defined criteria and indicators framework. The two-step approach helps in coherently prioritising relevant mitigation options from the entire list of available mitigation options.

In Table 43 the list of all mitigation options is reproduced from Section 4.

Table 43: List of mitigation options

S. No.	Mitigation Option
1	At source reduction and reuse
2	Recycling of dry materials
3.1	Biomethanation
3.2	Aerobic composting
3.3	Vermicomposting
4.1	RDF from MSW for co-processing in cement industry
4.2	RDF for power plants
4.3	RDF for thermal use in industry (other than cement)
4.4	Incineration plant for mixed MSW with electricity generation
4.5	Gasification, pyrolysis, plasma
5.1	Mechanical Biological Treatment (MBT)
5.2	Active LFG capture with electricity generation
5.3	Active LFG capture with flaring
5.4	Methane oxidation layer

For the **1st filter,** the aforementioned options are run through checks on following national policies & programmes (below table).

Table 44: National policies & programmes for 1st filter

S. No.	National policies
a	Service Level Benchmark
b	Guidelines on Swachh Bharat Abhiyan
c	Smart Cities Initiatives
d	JNNURM – I
e	National Mission on Sustainable Habitats (under NAPCC)
f	MSW Manual (Revised) – CPHEEO
g	MSW Rules 2000 (revised 2014)
h	MNRE - WTE policies

The outcome obtained is based on mapping of mitigation options against the national policies & programmes (1st filter) is depicted in Table 45.

Table 45: Evaluation of mitigation options based on 1st filter of criteria and indicator framework

SN	Mitigation option / evaluation criteria	Service Level Bench-mark	Guideli-nes on Swachh Bharat Abhiyan	Smart Cities Initiative	JNNURM – I	National Mission on Sustainable Habitats under NAPCC	MSW Manual (Revised) CPHEEO	MSW Rules 2000 (revised 2014)	MNRE – WTE policies
1	At source reduction and reuse	✓	✓	✓	✓	✓	✓	✓	✓
2	Recycling of dry materials	✓	✓	✓	✓	✓	✓	✓	✓
3.1	Biomethanation	✓	✓	✓	✓	✓	✓	✓	✓
3.2	Aerobic composting	✓	✓	✓	✓	✓	✓	✓	✓
3.3	Vermicomposting	✓	✓	✓	✓	✓	✓	✓	✓
4.1	RDF from MSW for co-processing in cement industry	✓	✓	✓	✓	✓	✓	✓	✓
4.2	RDF for power plants	✓	✓	✓	✓	✓	✓	✓	✓
4.3	RDF for thermal use in industry (other than cement)	✓	✓	✓	✓	✓	✓	✓	✓
4.4	Incineration plant for mixed MSW with electricity generation	✓	✓	✓	✓	✓	✓	✓	✓
4.5	Gasification, pyrolysis, plasma	✓	✓	✓	✓	✓	✓	✓	✓
5.1	Mechanical Biological Treatment (MBT)	✓	✓	✓	✓	✓	✓	✓	✓
5.2	Active LFG capture with electricity generation	✓	✓	✓	✓	✓	✓	✓	✓
5.3	Active LFG capture with flaring	✓	✓	✓	✓	✓	✓	✓	✓
5.4	Methane oxidation layer	✓	✓	✓	✓	✓	✓	✓	✓

✓ Consistent

× Not consistent

The above table shows that all 14 mitigation options obtained a positive response. As a next step, all the screened mitigation options from the **1st filter** are evaluated on the criteria and indicator framework (**2nd filter**) based on 5 categories, 21 criteria and 29 indicators as presented (below table). A **HIGH-MEDIUM-LOW** score has been used for evaluation of impacts.

Table 46: Evaluation of mitigation options based on 2nd filter of criteria & indicator framework

SN	Mitigation option/ evaluation criteria	GHG mitigation potential	SD - Economic	SD - Social	SD – Environmental	SD – Technology	Total Score
1	At source reduction and reuse	Not quantifiable	Medium	Low	High	Low	Medium
2	Recycling of dry materials	Low	High	High	Medium	Low	Medium
3.1	Biomethanation	High	Low	High	Medium	High	High
3.2	Aerobic composting	Medium	Low	High	High	High	High
3.3	Vermicomposting	Low	Low	High	High	Medium	Medium-High
4.1	RDF from MSW for co-processing in cement industry	High	Low	Medium	High	High	High
4.2	RDF for power plants	High	Low	Medium	Medium	High	Medium-High
4.3	RDF for thermal use in industry (other than cement)	Low	Low	Medium	Low	Low	Low
4.4	Incineration plant for mixed MSW with electricity generation	Low	Medium	Medium	Low	Medium	Low-Medium
4.5	Gasification, pyrolysis, plasma	High	Low	Low	High	Low	Medium
5.1	Mechanical Biological Treatment (MBT)	Medium	Low	High	Medium	High	Medium-high
5.2	Active LFG capture with electricity generation	Medium	Low	Low	Medium	Low	Low
5.3	Active LFG capture with flaring	Low	Low	Low	Medium	Low	Low
5.4	Methane oxidation layer	Not quantifiable	Low	Low	Medium	Medium	Low-Medium

Three options are scored high and two options are scored medium-high which are considered for further evaluation in Section 7.4. Low and low-medium options are excluded from further assessment.

7.2 EVALUATION OF POLICY INSTRUMENTS

Evaluation of policy instruments is more complex than that of mitigation options due to their inability to demonstrate direct impacts and therefore low MRV-ability. Therefore, initially, all the policy instruments (regulatory and fiscal) listed under Section 4 are checked for their alignment and consistency with the national policies and programmes mainly to avoid any conflict. In below table, the list of all policy instruments is reproduced from Section 4.

Table 47: List of policy instruments (regulatory and fiscal)

Regulatory policy instruments	
Applicable to all mitigation options:	
1.	Mandatory segregation of waste across value chain
2.	Single window clearance for waste management projects
3.	Facilitation of land identification & acquisition
Specific to mitigation options:	
4.	Facilitation of markets for recyclable materials and for other outputs e.g. compost and RDF
5.	Quality standards and label for compost
6.	Clear guidelines allowing inter-state transfer of waste in case of co-processing of waste
7.	Guidelines for pre-processing of waste in Industry
8.	Clear legislative framework and facilitated processing of electricity feed-in WTE or LFG projects
Fiscal policy instruments	
Direct fiscal support[21] :	
9.	Output based incentive through tipping fee for municipal waste received (treated)
10.	Government-specified price for purchase of recyclable materials/compost, feed-in-tariff for electricity from WTE or LFG projects
11.	Viability Gap Fund (VGF)
12.	Revolving Loan Fund (RLF)
13.	Tax and tariff exemption on plant & machinery for waste treatment technologies
14.	Tax incentives for recycled material
Indirect fiscal support:	
15.	Minimum user fee at household level for waste collection, segregation & transportation
16.	Access of ULBs to central government infrastructure funds contingent on achievement of SWM benchmarks
17.	Taxes on non-biodegradable consumer products
18.	Reduction of fertiliser subsidies

The aforementioned policy instruments are run through checks on national policies & programmes (Table 44) for assessing their alignment and consistency with the national policies and programmes. The outcome based on mapping of policy instruments against the national policies and programmes is depicted in Table 48.

Table 48: Evaluation of policy instruments based on 1st filter of criteria and indicator framework

SN	Policy instruments/ evaluation Cciteria	Service Level Bench-mark	Guidelines on Swachh Bharat Abhiyan	Smart Cities Initiative	JnNURM-I	NMSH under NAPCC	MSW Manual (Revised) CPHEEO	MSW Rules 2000 (revised 2014)	MNRE - WTE policies
	Regulatory policy instruments								
1	Mandatory segregation of waste across value chain	✓	✓	✓	✓	✓	✓	✓	✓
2	Single window clearance for waste management projects	✓	✓	✓	✓	✓	✓	✓	✓
3	Facilitation of land identification & acquisition	✓	✓	✓	✓	✓	✓	✓	✓

21 Direct fiscal support to private sector for processing of waste using mitigation option(s)

SN	Policy instruments/ evaluation Citeria	Service Level Bench-mark	Guidelines on Swachh Bharat Abhiyan	Smart Cities Initiative	JnNURM-I	NMSH under NAPCC	MSW Manual (Revised) CPHEEO	MSW Rules 2000 (revised 2014)	MNRE - WTE policies
4	Facilitation of markets for recyclable materials and for other outputs e.g. compost and RDF	✓	✓	✓	✓	✓	✓	✓	✓
5	Quality standards and label for compost	✓	✓	✓	✓	✓	✓	✓	✓
6	Clear guidelines allowing inter-state transfer of waste in case of co-processing of waste	✓	✓	✓	✓	✓	✓	✓	✓
7	Guidelines for pre-processing of waste in Industry	✓	✓	✓	✓	✓	✓	✓	✓
8	Clear legislative framework and facilitated processing of electricity feed-in WTE or LFG projects	✓	✓	✓	✓	✓	✓	✓	✓
	Fiscal policy instruments								
9	Output based incentive through tipping fee for municipal waste received (treated)	✓	✓	✓	✓	✓	✓	✓	✓
10	Government-specified price for purchase of recyclable materials/ compost, feed-in-tariff for electricity from WTE or LFG projects	✓	✓	✓	✓	✓	✓	✓	✓
11	Viability Gap Fund (VGF)	✓	✓	✓	✓	✓	✓	✓	✓
12	Revolving Loan Fund (RLF)	✓	✓	✓	✓	✓	✓	✓	✓
13	Tax and tariff exemption on plant & machinery for waste treatment technologies	✓	✓	✓	✓	✓	✓	✓	✓
14	Tax incentives for recycled material	✓	✓	✓	✓	✓	✓	✓	✓
15	Minimum user fee at household level for waste collection, segregation & transportation	✓	✓	✓	✓	✓	✓	✓	✓
16	Access of ULBs to central government infrastructure funds contingent on achievement of SWM benchmarks	✓	✓	✓	✓	✓	✓	✓	✓
17	Taxes on non-biodegradable consumer products	✓	✓	✓	✓	✓	✓	✓	✓
18	Reduction of fertiliser subsidies	✓	✓	✓	✓	✓	✓	✓	✓

It becomes clear from the above table that none of the identified regulatory and fiscal policy instruments is in conflict with the existing national policies and programmes.

As provided in Section 4, all **regulatory policy instruments** are divided into, (1) those which facilitate all or several mitigation options and (2) those which are directed towards a single mitigation option. For the purpose of this study, regulatory policy instruments which are able to target all or several mitigation options have been selected for further analysis due to their far reaching potential of impacting mitigation in the sector. For example, a regulatory policy instrument promoting *segregation of waste across value chain* would have far reaching positive impact across mitigation options in terms of effectiveness, performance, willingness of private sector to participate among others. Similarly, regulatory policy instruments like *single window clearance for waste management projects and facilitation of land identification & acquisition* would be applicable to all mitigation options and therefore, have more potential to reduce GHG emissions from MSW sector in India.

Further, an analysis below of identified policy instruments provides information about their suitability to the sector.

Table 49: Evaluation of regulatory instruments

Regulatory policy instruments	Potential impact	Remarks
R1 – Mandatory segregation of waste across value chain	High	Enhances effectiveness/suitability of multiple mitigation options e.g. pre-segregated waste will help reduce resource requirement of RDF plants
R2 – Single window clearance for waste management projects	High	Enhances ease of doing business; attracts investment from within and outside the country in the sector
R3 – Facilitation of land identification & acquisition	Medium	Enhances ease of doing business; promotes public-private partnership; will fasten implementation; large cities will still face problem in identifying suitable land for large projects
R4 – Facilitation of markets for recyclable materials and for other outputs e.g. compost	Medium-high	Enhances projects' viability; limited applicability to mitigation options e.g. at source reduction
R5 – Quality standards and label for compost	Low	Supports market creation for compost usage at a wider scale; enhances confidence of farmers; in line with GOI's soil testing programme; capacity constraints
R6 – Clear guidelines allowing inter-state transfer of waste in case of co-processing of waste	Medium	Will facilitate use of waste in cement industries which are located in other states; expands market for waste derived fuels e.g. RDF
R7 – Guidelines for pre-processing of waste in industry	High	Supports pre-processing industry for which cement industry/ other energy users will be the market
R8 - Clear legislative framework and facilitated processing of electricity feed-in WTE or LFG projects	Low	Least preferred option in the hierarchy of waste

The **fiscal policy instruments** are divided on the basis of direct and indirect support to the waste sector. A fiscal policy instrument providing *direct incentives with technology differentiated result based payments* will have wider applicability and therefore wider impact on mitigation and other co-benefits.

Table 50: Evaluation of fiscal instruments

Fiscal policy instruments	Potential impact	Remarks
F1 – Output based incentive through tipping fee for municipal waste received (treated)	High	Guarantees performance, prevents leakage to badly designed/ operating projects; technology-differentiated support can be provided; impact is measurable
F2 – Government-specified price for purchase of recyclable materials/ compost, feed-in-tariff for electricity from WTE projects	Medium	Clarity of support available so decision making is easier at the promoter level; some projects may still not be viable at pre-fixed prices e.g. high transport cost due to long distances from collection to processing of waste might require more support
F3 – Viability Gap Fund (VGF)	Low	Enhances project viability; does not guarantee sustained operation of the projects
F4 – Revolving Loan Fund (RLF)	Medium	Per project financing support is lower; can support more number of projects; lower cost of finance further enhances project viability
F5 – Tax and tariff exemption on plant & machinery for waste treatment technologies;	Medium	Enhances project viability, project performance at the optimal levels not guaranteed once tax benefits have been availed by the developer
F6 - Tax incentives for recycled material	Low	Need design change at production level where recycled material is introduced as input.
F7 – Minimum user fee at household level for waste collection, segregation & transportation	Medium	ULBs will be able to generate revenue; households will push ULBs for better services in return
F8 - Access of ULBs to central government infrastructure funds contingent on achievement of SWM benchmarks	High	Financing linked to performance will incentivize better projects and management practices at ULB level; high political acceptance
F9 – Taxes on non-biodegradable consumer products	Low	Alternatives unavailable in short-medium term; market awareness/ acceptance low
F10 – Reduction of fertiliser subsidies	Low	Not enough available compost capacity to meet the entire demand; low political capital for enforcement.

Further prioritisation of fiscal policy instruments is discussed in detail in Section 7.5.

7.3 EVALUATION OF READINESS OF INSTITUTIONS FOR ADMINISTERING THE POLICIES AND PROGRAMMES

Next to narrowing down the mitigation options and policies, it is essential to also take into account the readiness of the institutions in India for administering the policies and programmes and the challenges that these institutions are facing.

ULBs that are formally in charge of SWM policies are severely challenged due to their inability to collect waste fees from the population. In some cases, personal dedication of commissioners and city waste management staff has led to “islands of performance“, but the vast majority of ULBs has not been able to introduce sustainable SWM.

SPCBs are principally well placed to serve as auditing entities for policy performance but have not fulfilled this role due to lack of human capacity.

Private sector companies have tried to implement large-scale waste treatment plants, mainly WTE and LFG, and only a small share of them has been able to operate them successfully in the long run.

Municipal solid waste management is on a transitional phase in India with a lot of pressures to perform on account of judicial oversight, the rulings of National Green Tribunal, environmental activists and well aware citizens.

A classical case is the **City of Bangalore**, where a working system collapsed due to various reasons, presenting an opportunity to all stakeholders to start afresh and usher in novel and radical changes and also try out various models of centralised and decentralised solid waste management. The city has thus been able to galvanise itself to take on the challenges on short notice. We therefore provide a case study from Bangalore, where SWM is developed and showcases the readiness of various institutions to respond to the situation and adapt their work to suit the demands of the MSW situation.

7.3.1 Bangalore case study

Bangalore is the capital of the South Indian state of Karnataka and is one of the five large cities of India. It has a geographical area of 800 km2 and an urban population of 8.42 million (BBMP, no year). The city currently generates about 3,600 TPD of municipal waste from all sources. As per the Karnataka Municipal Corporation Act, 1977, the Bruhat Bengaluru Mahanagara Pallike (BBMP) is responsible for the management of the MSW. The BBMP has outsourced nearly 70% of the MSW work of collection to disposal to private parties (Expert Committee on Municipal Waste Management by Bruhat Bengaluru Mahanagara Palike, 2013; BBMP, no year).

The Karnataka State Pollution Control Board in August 2012 ordered the Mavalipura Landfill to be temporarily closed to enable site cleanup. This aggravated the situation, but also presented an opportunity to introduce systemic corrections. The crisis was caused due to indiscriminate dumping of mixed waste to the compost plants for a tipping fee, with no processing nor any treatment of the leachate to prevent ground water contamination and pollution.

BBMP carried out a cause and effect analysis for waste management. An analysis of problems and problem areas revealed that the present SWM situation is a sub-standard, inefficient and dysfunctional system hampered by serious organisational and technical issues.

Acting on the directions of the Hon'ble Karnataka High Court and Lok Adalat in several court cases, BBMP took the initiative in making SWM a sustainably managed system. The key principles that BBMP considered in the adoption of a proper SWM plan are (Expert Committee on Municipal Waste Management by Bruhat Bengaluru Mahanagara Palike, 2013):

- Incorporate principles of sustainable development
- Define and implement the waste hierarchy (reduction, reuse, recycling, recovery & disposal)
- Define producer responsibility and require accountability
- Incorporate polluter pay principles
- Use best practicable environmental options
- Define roles & responsibilities for stakeholders

The expert committee constituted to advise the BBMP produced a report which suggested key actions and recommendations popularly known as the "XC report" (ibid, 2013). The BBMP in its follow up action has tried to implement all the recommendations. Various stakeholders, other government departments, PPP operators, NGOs, citizens have all been involved in various aspects of this action plan. The key aspects are detailed below.

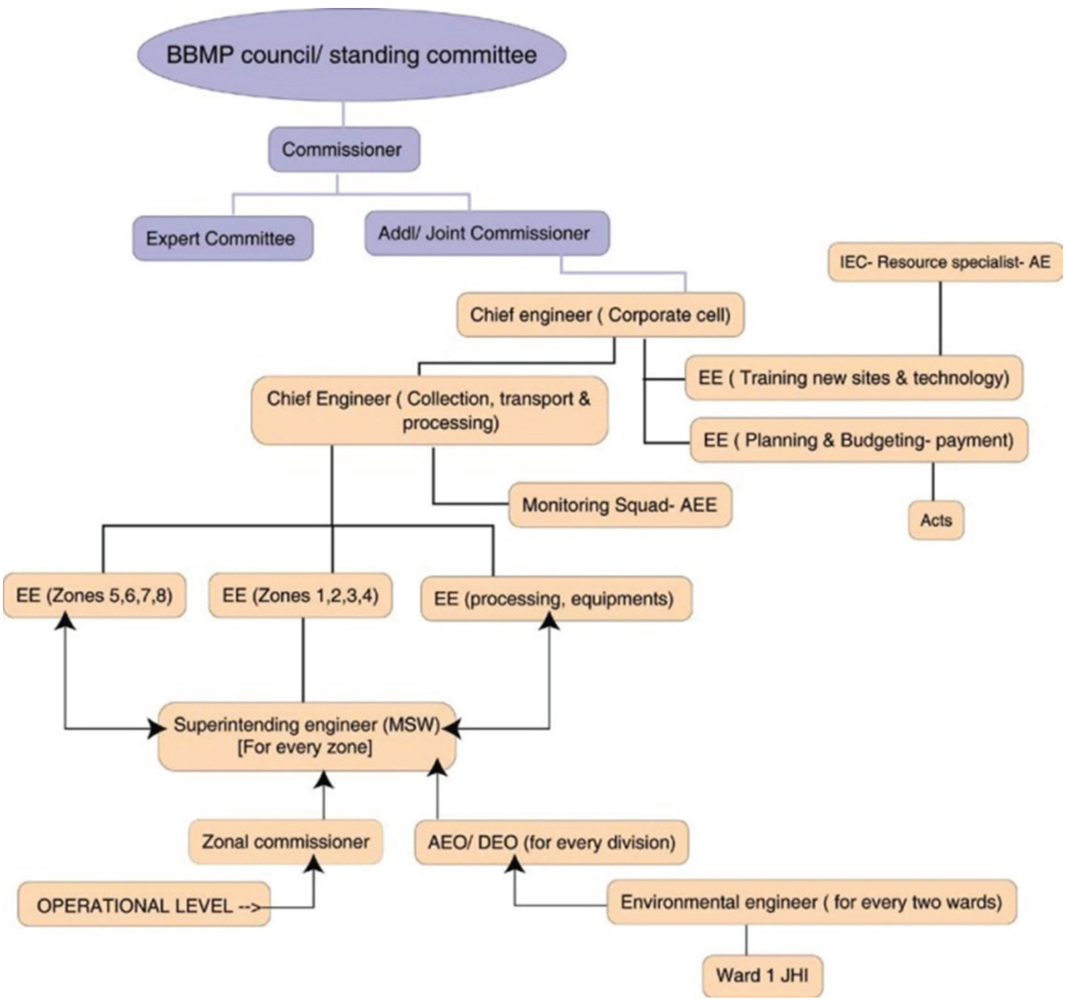
1. Policy & legislative aspects

The BBMP initiated the whole process by issuing a notification detailing out the waste handling procedures and destinations for six different streams (wet, dry, C&D, sanitary/biomedical waste, domestic hazardous waste and e-waste) and to be implemented on a time-bound basis. It also made it mandatory for all citizens to segregate waste at source in all its 198 wards. The bulk generators were identified and in conformance to the "polluter pays" principle were obliged to manage their own waste. All new projects are required to implement a decentralised SWM as a prerequisite for obtaining building permission.

2. Organisational set-up

Figure 32 shows the proposed organisational set-up:

Figure 32: Suggested organisational set-up (Expert Committee on Municipal Waste Management by Bruhat Bengaluru Mahanagara Palike, 2013)



The BBMP prepared a draft action plan with a short term, medium and long term vision for the city. In line with the XC Report and the long-term action plan, a separate cell was created headed by a special commissioner to look after the MSW. He is supported by a dedicated set of officers who are responsible for MSW as per the organisation structure indicated above.

3. Technical/operational aspects

BBMP carried out an empanelment process to enlist vendors and service providers who can be outsourced with the processing and disposal of MSW. It also, with the support of the Karnataka Urban Infrastructure Development Corporation, initiated the construction of seven processing plants in various locations. The collection contracts were tweaked to ensure streamlined collection of segregated waste. 28 decentralised waste processing plants with biomethanation and aerobic composting initiated with active participation of NGOs. It also established and notified about 141 Dry Waste Collection Centres (DWCC) with a waste buyback tariff for dry recyclable waste. This was carried out by enlisting the services of informal recyclers or Kabaddiwalas.

4. Financial issues

The BBMP has initiated a user fee for SWM which is collected from citizens through the property tax. The empanelment of vendors was initiated with several conditions to encourage social enterprises, entrepreneurs and environmental companies to participate in collection, transfer, storage and recycling and processing using principles of decentralisation. All non-performing vendors are to be black-listed. Volumetric weighing of segregated quantities and GPS-tracking for all transport is aimed at to ensure weighing of all categories and linking to payment.

The new contract model adopted encourages segregation at source with stringent penal action for non-compliance, followed by processing and recycling at designated locations. Excluding the bulk generators as per the notification under the concept of polluter pays have resulted in lower volumes for BBMP. The shared services quantum is to be reduced from the total quantum of waste being processed by BBMP. This is essential to ensure there is no double counting and BBMP is not paying processing/tipping fee for waste being handled outside the BBMP mainstream. The tipping-fee concept is planned to be replaced by a "Support Price" to the compost (or processed end-product), similar to the KCDC model in all fresh tenders

5. Human resources

As stated earlier, an efficient dedicated SWM with clear roles and responsibilities has been established and headed by a special commissioner of a senior IAS rank. The BBMP has also constituted an "Expert Committee" comprising experts from various fields to advise them on SWM matter.

6. Public awareness/stakeholders

An effective "Communication Plan" has been developed to educate and make citizens aware at all levels: about waste, their role and the programmes of the BBMP, which are prominently displayed in the BBMP website, ward office and print media. The local corporators/ elected members also communicate the initiatives to the respective ward citizens. In cooperation with the Environmental Management and Policy Research Institute (EMPRI), Govt. of Karnataka, BBMP has conducted trainings for all the eight zones covering 199 wards. The target group included all senior supervisory staff and environmental engineers of the zones. EMPRI has co-opted reputed institutions and sector experts to carry out the trainings. The trainings are repeated every year. Videos of model SWM have been created to engage with local public. BBMP has also involved citizen groups and Resident Welfare Associations (RWA) as part of the strategy for the community outreach programme.

A summary of the actions suggested by the expert committee and initiative undertaken is tabulated overleaf.

Table 51: Readiness of institutions in administering policies and programmes – actions suggested within BBMP case study

(Expert Committee on Municipal Waste Management by Bruhat Bengaluru Mahanagara Palike, 2013)

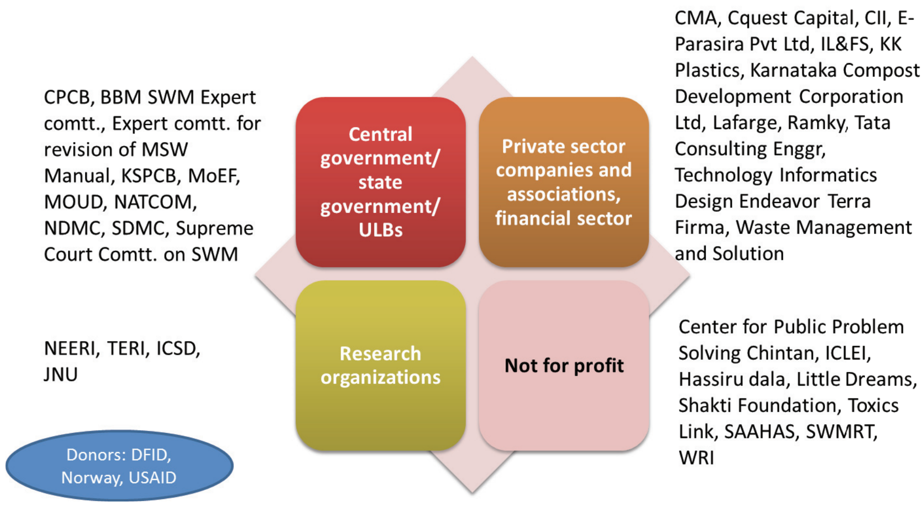
Problem area	Problems	Policy support	Agency	Support agency	Present status
1. Policy & Legislative	Lack of framework and vision	Develop city solid waste plan	BBMP	Urban Development Department (UDD), Directorate of Municipal Administration (DMA), GOK	Plan prepared
	Incomplete legislation	Amend Karnataka Municipal Act	UDD, DMA, GOK		Notification issued
	Lack of monitoring & enforcement	Empower agencies/build capacity	KSPCB	Dept of Ecology and Environment, UDD, GOK	Yet to be done
2. Institutional/ Organisational	Lack of SWM division in BBMP	Organisational Change	BBMP	Expert committee	Ongoing
	Roles & responsibili-ties not defined. Dual responsibility of SWM staff	Organisational Change	BBMP	Expert committee/ Consultants	Special commissioner appointed / SWM officers designated
	Lack of use of economic instruments	Define appropriate instruments	BBMP	UDD, GOK	SWM cess notified for different generators
	Inappropriate conditions for private sector participation	Frame model tender condition	BBMP	Infrastructure Development Department (IDD)/ Finance department (FD), GOK	Enabling conditions introduced in tenders
3. Technical/ operational	Improper organisation / coverage for waste collection and transfer from primary to secondary transport vehicles	Recruit more staff and provide resources	BBMP	Urban Development Department, GOK	Pilot study being conducted to establish normatives
	Lack of standards for MSW collection, treatment & disposal	Review Directorate of Municipal Administration Standards	BBMP	Urban Development Department, Directorate Municipal Administration (DMA), GOK	Pilot study being conducted to establish normatives
	Lack of pre-treatment & treatment facilities	Implement pretreatment/ treatment infrastructure	BBMP	IDD, FD, GOK	28 dry water collection centers established
	Lack of segregation of wastes at source	Amend bylaws/ Notification	BBMP/ residents	KSPCB, UDD, DMA	Notification introduced. 45 wards out of 199 segregation implemented
	Inefficient operation of processing units and landfills	Amend Tender/ Contract	BBMP/ PPP operators	KSPCB, UDD/DMA	7 new projects under constructions to be commissioned this year with 2350TPD capacity

Problem area	Problems	Policy support	Agency	Support agency	Present status
	Lack of separate collection system for special wastes like debris, garden waste	Introduce separate collection	BBMP/ NGOs	Expert Committee , KSPCB,	Separate collections already piloted in 45 wards. Studies on destination based movements ongoing 5 new sites identified for c & D waste
	Lack of organised market for recyclables	Formalise recyclers	NGOs/ BBMP	Expert committee/ Dept of Social welfare and Labour	28 Dry waste centres established formalizing the recyclers
4. Financial Issues	Low municipal cost recovery Lack of economic instruments to bring change	Assess real cost Amend byelaws to introduce appropriate economic instruments	BBMP	UDD, GOK	Studies ongoing SWM user charges levied
	Lack of sufficient funds for SWM infrastructure	Avail State/ Central finance Viability Gap Funds VGF	BBMP	FD, KUIDFC	External funding provided
	Lack of standards for involvement of private sector	PPP policy/ Develop Model Contract models	BBMP	UDD/IDD/DMA	Projects allotted on PPP basis
	Lack of incentives for market development	Subsidies/ VGF/ product support prices	BBMP	UDD/IDD	Product support prices introduced
5. Human Resources	Lack of dedicated team responsible for SWM Lack of trained staff	Conduct Role clarity exercise Establish training courses Develop capacity	BBMP	Academics, KSPCB, UDD/DMA	Trainings being conducted by EMPRI
	Weak monitoring / enforcement capability	Provide resources Empanel laboratory Third party agencies	BBMP	KSPCB/UDD/DMA	GPS/GPRS systems, Video cameras at plant, Handheld ticketing systems for monitoring introduced
	Lack of standards to assess quality of service	Establish graded service standards	BBMP	UDD/DMA	Pilot studies being conducted
	Lack of responsibility & accountability Lack of well-defined command chain	Establish a command structure	BBMP	UDD/DMA	Organisational structure created
6. Public Awareness/ Stakeholders	Lack of public awareness strategy with the general public Lack of communication at all levels with the stake holders Lack of capacity building and framework for training and skill enhancement	Develop IEC strategy Communicate City SWM plan	BBMP	UDD/DMA/NGOs Resident welfare association RWAs	IEC strategy, consultation with stakeholders introduced

7.4 PRIORITISATION OF MITIGATION OPTIONS

The mitigation options and policies listed in section 4 have been evaluated by the study team according to the criteria set developed in Section 3.[22] This evaluation also takes into account the feedback from the stakeholder consultations undertaken between November 2014 and March 2015 (see Figure 33). Its aim is to prioritise a subset of mitigation options whose structuration as a NAMA will then be described in Section 9.

Figure 33: Stakeholders consulted



In the following, the mitigation options are prioritised according to waste hierarchy:

The highest layer of the waste hierarchy, ***at source reduction and reuse***, is challenging regarding the estimation of GHG mitigation, as there are no universally accepted methodologies for this mitigation option. While its economic and environmental benefits are high due to the reduction of waste management costs and pollution related to waste, social and technological benefits would be low given that jobs in waste management would decrease and thus overall evaluation would reach a **medium** level.

The second waste hierarchy layer, ***recycling of dry materials***, has a relatively low GHG mitigation potential given the already high share of paper and metal recycling. While its economic and social benefits of recycling are high due to the economic attractiveness of collection of recyclables as well as high labour intensity, environmental benefits are medium due to the emissions linked to the recycling process. Given the low technology intensity of recycling, technology benefits are low. The total score of this option is thus **medium**.

In the third layer of the waste hierarchy***, aerobic composting*** has a medium level mitigation potential given the relatively small size of plants. It scores highly for all criteria except the economic one, which is low due to the absence of real market for compost. Overall score is **high**.

Vermicomposting scores somewhat lower (**medium-high**) as its mitigation potential is low and technology benefits are medium given that this option does not involve technology development.

Biomethanation has a high mitigation potential if the scale of plants can be increased, and scores highly for social and technological benefits. The latter accrue if technology transfer can be implemented that allows use of larger plants. Environmental benefits are medium given that the

22

replaced natural gas is a relatively clean fuel, while economic benefits remain low at the current status of technologies. Overall, this mitigation option scores **highly**.

The fourth level of the waste hierarchy includes all RDF-based options as well as incineration and complex technologies such as gasification, pyrolysis and plasma. ***RDF from MSW for co-processing in cement industry*** has a high technical potential. However, as long as cement plants are unwilling to pay for the RDF, its economic benefits are low. Environmental and technological scores are high due to the high temperature of the process that reduces pollution, and the characteristics of the technology being mastered by a number of middle income countries. The overall score is **high.**

RDF for power plant scores similarly for all criteria except the environmental one, where due to lower incineration temperatures the generation of harmful substances cannot be excluded. It thus achieves a **medium-high** score.

RDF for thermal use in industry (other than cement) has a low mitigation potential, and scores low regarding economic, environmental and technological benefits. This is due to the lack of willingness to pay, the high pollution linked to substandard incineration technologies used by small and medium enterprises and their inability to apply improved technologies. This option thus scores **low**.

Incineration plant for mixed MSW with electricity generation has a low mitigation potential given repeated failures to apply this technology under Indian conditions. Economic, social and technological benefits are medium given that electricity generation costs are comparable to those of small fossil fuel plants, some skilled jobs are created and the technology is principally available in India, but requires some transfer. Total score is **low-medium**.

Gasification, pyrolysis, plasma principally have a high mitigation potential. Given the high costs of the technologies, lack of experience with their utilization under Indian conditions and small number of jobs created, they score low with regard to economic, technological and social criteria. Environmental benefits would be high as pollution is reduced strongly. This option scores **medium**.

The lowest layer of the waste hierarchy related to landfills includes four mitigation options. ***Mechanical Biological Treatment (MBT)*** has a medium mitigation potential. It scores highly regarding social and technological benefits given the creation of relatively skilled jobs and the medium complexity of the technology. Environmental benefits are medium given that the waste is only becoming inert. Economic benefits are low given no revenue accrues from selling products. The overall score for MBT is medium-high.

LFG capture with electricity generation has a medium mitigation potential. It scores low with regard to its economic, social and technological benefits. Costs of electricity generation are higher than of alternative power generation technologies. The creation of skilled jobs is low. Performance of the technology under Indian conditions is unclear. Environmental benefits are medium due to the avoidance of fossil fuel burning. ***LFG capture with flaring*** has a lower mitigation potential and scores similarly with regard to the other criteria. Overall scores for both mitigation options are **low**.

The mitigation potential of ***methane oxidation layers*** cannot be quantified. Its economic and social benefits would be low given that it generates no products that can be sold, nor skilled jobs. Environmental and technological benefits would be medium given the pollution reduction benefit linked to the better management of the landfill and the relatively simple character of the technology; the total score reaches **low-medium**.

All mitigation options that achieve a high score are retained for NAMA development (see below table). We also include similar mitigation options with a "medium-high" score.

Table 52: Prioritisation of mitigation options

Sl No.	Evaluation Criteria Mitigation options	GHG Mitigation Potential	SD-Economic	SD-Social	SD- Environmental	SD-Technology	Total Score	Prioritization
1	At Source Reduction and Reuse	Not quanti fiable	High	Low	High	Low	Medium	
2	Recycling of Dry Materials	Low	High	High	Medium	Low	Medium	
3.1	Aerobic composting	Medium	Low	High	High	High	High	X
3.2	Vermi-Composting	Low	Low	High	High	Medium	Medium-High	(X)
3.3	Biomethanation	High	Low	High	Medium	High	High	X
4.1	RDF from MSW for co-processing in cement industry	High	Low	Medium	High	High	High	X
4.2	RDF for power plants	High	Low	Medium	Medium	High	Medium-High	(X)
4.3	RDF for thermal use in industry (other than cement)	Low	Low	Medium	Low	Low	Low	
4.4	Incineration plantfor mixed MSW with electricity generation	Low	Medium	Medium	Low	Medium	Low-Medium	
4.5	Gasification, pyrolysis, plasma	High	Low	Low	High	Low	Medium	
5.1	Mechanical Biological Treatment (MBT)	Medium	Low	High	Medium	High	Medium-high	
5.2	Active LFG capture with electricity generation	Medium	Low	Low	Medium	Low	Low	
5.3	Active LFG capture with flaring	Low	Low	Low	Medium	Low	Low	
5.4	Methane oxidation layer	Not quantifiable	Low	Low	Medium	Medium	Low-Medium	

The **Aerobic composting, Vermicomposting, Biomethanation, RDF from MSW for co-processing in cement industry** and **RDF for power plants would thus be prioritised.** It should be noted that these mitigation options feature in the middle of the marginal abatement cost curve developed in Section 6, thus are neither particularly "cheap" nor "expensive".

For the development of a package of regulatory and fiscal policy instruments for these prioritised options see Section 7.5 below.

7.5 PRIORITISATION OF MITIGATION POLICIES IN THE SWM SECTOR

Section 4 has shown that to date regulatory policy instruments have failed to lead to a highly performing MSW management in India. Regulation is either ignored or only partially implemented. CDM projects have shown that revenues for mitigation from waste have mobilised private companies to engage in the sector. Nevertheless, performance has been worse than expected, showing the need to combine regulatory and fiscal policy instruments. The latter can only work if the regulatory policy instruments provide a framework where technology operation is not stopped due to lack of waste / insufficient waste quality.

The highest priority must be on policy instruments that provide a performance-based incentive for waste treatment as well as mitigation of GHG. These include output based incentives through tipping fees for municipal waste treated and a Viability Gap Fund to achieve revenue that is sufficiently attractive to mobilize projects. Any institution, be it private sector companies or NGOs should be eligible for all types of incentive. Moreover, ULBs should be incentivised to achieve full segregation of waste streams at source, involving wastepicker cooperatives. Given the success with performance based incentives in the Indian renewable energy industry, waste sector managers should learn from the experiences in introducing these incentives.

The advantage of a policy-based approach is that it can mobilise various mitigation options in parallel. If desired, policymakers can exclude specific technologies that are seen as providing limited benefits, e.g. landfill-related mitigation options or gasification, pyrolysis and plasma.

But it is also possible to design a package of policy instruments tailored towards specific mitigation options.

E.g., for the mitigation options prioritised in Section 7.4 above, this could look as follows:

For ***RDF from MSW for co-processing in the cement industry***, the following policy instruments would be proposed in order to mobilise RDF processing facilities:

Regulatory policy instruments:

- Guidelines allowing inter-state transfer of waste in case of co-processing of waste
- Definition of waste types applicable for all states
- Guidelines for pre-processing of waste in the cement industry

Fiscal policy instruments:

- Output based incentives through tipping fees for municipal waste treated
- Viability Gap Fund
- Revolving Loan Fund

For ***composting and vermicomposting*** instruments would include:

Regulatory policy instruments:

- Facilitation of land identification & acquisition
- Quality standards and label for compost
- Uptake requirement of unsold compost by forest / agricultural department

Fiscal policy instruments:

- Viability Gap Fund
- Government-specified price for purchase of compost
- Output based incentives through tipping fees for municipal waste treated

For ***biomethanation***, the approach would be as follows:

- Regulatory policy instruments:
- Enforcement of mandatory segregation of waste at household level
- Facilitation of land identification & acquisition

Fiscal policy instruments:

- Output based incentives through tipping fees for municipal waste treated
- Viability Gap Fund
- Feed in tariff for electricity

A monitoring, reporting and verification (MRV) approach for the prioritised policies and mitigation options

8

For the prioritized SWM mitigation options and policy instruments, a concept for a MRV system is developed taking into account the criteria and indicators developed above.

8.1 EXISTING MRV IN THE SWM SECTOR

To date MRV in Indian SWM is almost non-existent. Only large-scale, well managed composting plants weigh waste inflows and sample shares of the various waste fractions. Likewise, a few NGO-managed small scale composting and biomethanation plants have been able to monitor in- and outflows. Generally, plants that produce an output (electricity, gas, compost) monitor this relatively well, but input monitoring is less elaborated.

Service Level Benchmark (SLB) is an initiative by Ministry of Urban development, Government of India (GoI), to monitor the performance of Urban Local Bodies (ULBs). For SLB, a standardized set of indicators has been put forward per definite framework, which the GOI intends to integrate in all future programmes to measure the level of service. The SLBs also define a benchmark which ULBs are supposed to achieve. These performance measurements will need to be carried out by the service delivery agencies themselves, reported to higher levels of management and also disseminated widely.

Roles of different stakeholders in SLBs:

- **Central Government:**

  The Ministry of Urban Development, GoI, has taken the lead in disseminating these SLB parameters and building wider acceptance by institutionalizing through the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and other programmes of this Ministry. SLB is an integral part of City Development Planning processes, both, for assessment of current situation and for setting targets under their plans and shall be dovetailed with the commitment on reforms, and subsequent process of appraisal of reforms. The relevant SLBs should be part of

Detailed Project Reports for concerned sectors, indicating both the current situation and what change the project will bring about. Subsequent processes of monitoring implementation of the project will also examine these SLBs. Support may be extended to enable ULBs and other civic agencies to establish systems in their respective institutions for periodic measurement, reporting and analysis of SLBs.

- **State Governments and its agencies:**

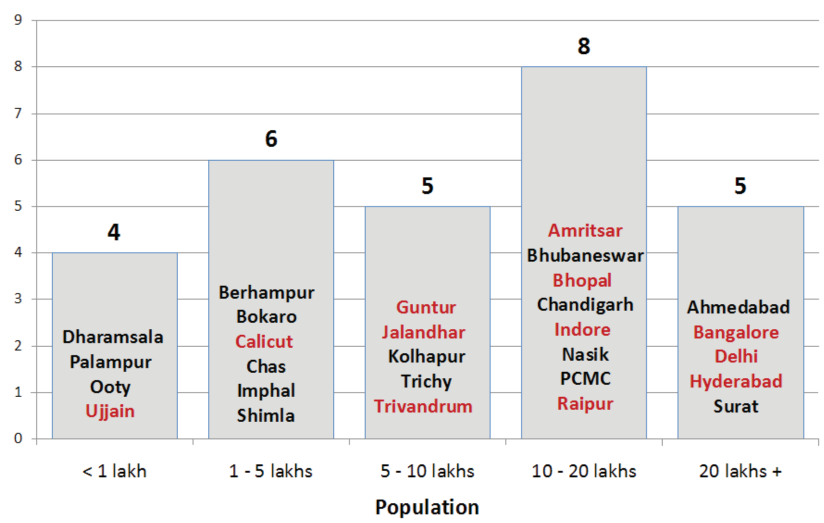
  State Governments and its nodal agencies in the urban sector have a critical role in driving performance of ULBs and city level civic agencies. State Government will need to periodically examine the SLBs as an input for its decisions related to policy, resource allocations, providing incentives and penalties, channelling technical and manpower support, and regulatory considerations amongst others. The Directorate of Local Bodies / Department of Municipal Administration will need to play a key role in this process through constant inter-city comparisons. These departments should leverage the power of information technology to build and operate systems that periodically capture and report on SLBs. Web-based technologies should be leveraged for managing information flow. For other nodal state level agencies, the SLBs will provide specific inputs for their programs and interface with the ULBs and other civic agencies. SLBs will also be an important input to State Finance Commissions in the course of their work.

- **Urban Local Bodies:**

  ULBs are the most important stakeholders for institutionalization of SLBs. As service delivery institutions, ULBs will find it useful to institutionalize systems for performance management using SLBs. Performance data at the sub ULB level (zone or ward level) is particularly useful for the ULB for taking appropriate decisions and monitoring performance of the various field units. Benchmarking with other cities within the State, or with similar cities facilitate a healthy competitive environment for continuous improvement.

A pilot study has been done by Administrative Staff College of India (ASCI), Hyderabad, for the 28 pilot cities implementing the SLB framework under the initiative of GOI (ASCI, 2010). The details of cities and key findings for the cities are shown in Figure 34:

Figure 34: Results from pilot cities implementing the SLB framework (ASCI, 2010)



Note: City names in red mean that water supply has also been assessed

Broad Reult – Solid Waster Management

Indicator	Benchmark	
1. Household level coverage	100%	49.1
2. Collection efficiency of MSW	100%	78.3
3. Segregation of MSW	100%	21.2
4. MSW recovery	80%	43.5
5. Scientific Disposal of MSW	100%	–
6. Cost recovery - SWM	100%	36.9
7. Collection efficiency	90%	67.3
8. Complaints redressal	80%	94.7

Currently all the ULBs are compiling this information and reporting to the respective UDD of the state. The measurement of the attributes is acquired by the ULBs either from its own staff or from its outsourced contractors or PPP partners who are obligated to report. The information is also not verified at present and consequently, several inconsistencies can be noticed during compilation. Currently almost all ULBs report information based on the Reliability data class D.

The Service Level Benchmarking is further explained in Section 8.3 below.

Companies that have been engaged in CDM projects and achieved issuance of CERs have gained experience in monitoring of various parameters over prolonged periods. For example, the Okhla compost plant in New Delhi (CDM project #2,470) monitors the following data since June 2009:

- Electricity consumption for equipment used on site through electricity meter
- Fuel consumption for equipment used on site through received invoices for fuel
- Produced compost transported from site through invoices
- Quantity of fresh waste arriving through weighbridge
- Composition of the incoming waste through weekly sample
- Number and detail of vehicles that bring in the waste and that transport compost to the end user
- Distance from compost plant to compost wholesale warehouses
- Survey of 24 sites where the compost is used

The 6 MW RDF power plant at Vijayawada (CDM project #959) monitored the following parameters between January 2004 and December 2007:

- Quantity of fresh waste arriving through weighbridge
- Composition of the incoming waste through monthly sample
- RDF burned through weighbridge
- Electricity production through electricity meter
- Auxiliary electricity consumption through electricity meter
- Fuel consumption for equipment used on site
- Number of truck loads from RDF plant to power plant
- Ash delivered to brick producers through counting truck loads

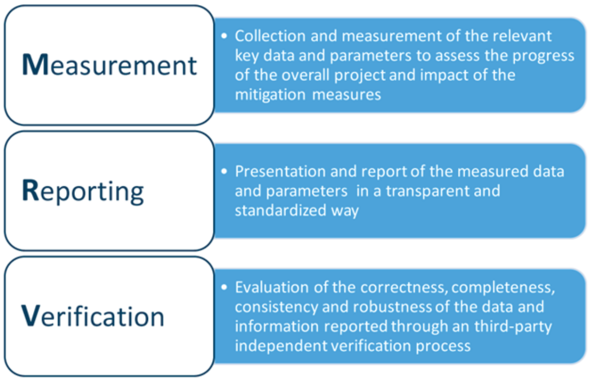
Given the critical status of the CDM market, it is important to identify the experts involved in monitoring of these CDM projects and to involve them in capacity building efforts for institutions that will be responsible for MRV under the NAMA.

8.2 IDEAL MRV SYSTEM IN THE SWM SECTOR

This section outlines the main design criteria for an MRV system appropriate for a SWM NAMA, i.e. the "blueprint" for such a system. The specific performance metrics and indicators for the MRV system to be applied during implementation of the SWM NAMA are preliminarily defined in Section 9.3 of this Feasibility Study, considering potential barriers and feasibility of MRV implementation in the Indian context.

The following figure shows the definitions of the principal components of an MRV system: Measurement, Reporting and Verification.

Figure 35: Definition of the Measurement, Reporting and Verification components of an MRV system (own elaboration, based on UNFCCC et al., 2013)



The main objectives of the MRV system are:

- to measure, monitor and control the degree of fulfilment of the objectives and goals set for the prioritized SWM mitigation options and policies, as well as for the other fields to be monitored: sustainable development benefits and NAMA support;
- to generate transparency and build trust regarding the effectiveness of the selected mitigation actions as well as the other fields of monitoring, including the financial flows, among potential supporters of the NAMA and with regard to global recognition for the NAMA; and
- to allow to adjust NAMA implementation over time.

General criteria and good practices for the MRV system:

The MRV system for a SWM NAMA should be built on the good practices for the development of a robust MRV system as named in UNFCCC et al. (2013), and on additional criteria:

Table 53: Good practices for the design of a robust MRV system (adapted and extended from UNFCCC et al., 2013)

Suggested Good Practice	Description
Accuracy	The measurement of the data and parameters of the MRV system should be conducted in the most precise way as possible and with the least uncertainty: it should be as accurate as the NAMA MRV budget allows (cost-effectiveness). Moreover, if there is the need to make a trade-off in the accuracy of the measurement, one should increase the conservativeness in the estimates and judgments. However, the stringency of the MRV system can vary significantly between technologies, between fields of monitoring, and between supported and unilateral elements of the NAMA.
Completeness	A robust MRV system should be able to cover all the relevant information related to all the effects caused by the implementation of the mitigation measures of the NAMA and the other fields of monitoring. In case some the impacts of the NAMA are estimated, the calculation methodology should be clearly and transparently described, including all the steps of the process.
Conservativeness	All the estimates and measurements should be made following a conservative approach, especially in situations when either the measurement or the estimation have high levels of uncertainty or when deploying a high level of accuracy in the measurement would not be cost-effective. The measurement methodology should identify the level of uncertainty in the measurement and include procedures for including conservative values (e.g. using IPCC default values when a measurement is not possible/not cost-effective).
Consistency	At least at a national level, the reporting of data and information should be consistent among different NAMAs, especially in the light of the reporting of INDCs (e.g. harmonisation of MRV systems at a national level). Moreover, within the same NAMA, the measurement taken at different periods of time should be consistent.
Comparability	Similarly to the consistency principle, the information gathered and data measured should be comparable across NAMA and across different periods of time, especially in the light of the reporting of INDCs. It is then advised to use clear processes for the measuring and standardised formats for the reporting, harmonising the MRV systems at a national level.
Transparency	Funders and the international community give a lot of importance to the transparency of the methodologies and processes used for the measuring and calculations of GHG emission reduction in an MRV system. A robust MRV should include a clear explanation for all the data gathered and calculations performed, in order to allow an independent third party perform the same measurement of calculation obtaining the same results.
Economic feasibility and cost-effectiveness	The MRV system should be as cost-efficient as possible, and financial viability, transaction costs and complexity should be always taken into account, in order not to represent a barrier for NAMA implementation.
Institutional feasibility	The MRV system should consider the institutional capacities of the involved actors, especially at decentralized (e.g. municipal) level and with regard to data collection, data quality and data reliability in reporting, as well as for the institutions assigned for the verification process.

Summarizing, an MRV system of a NAMA should have a good balance among robustness and completeness on the one hand, and simplicity and cost-effectiveness on the other hand.

Fields of monitoring

The MRV system has to encompass the following three fields of monitoring:

1. Prioritized SWM mitigation options:

The mitigation options prioritized will be measured, reported and verified in terms of their emissions reductions. Indicators will be measured at each individual source of information, such as mitigation projects or entities, and the data is then subsequently aggregated. Other technologies that are triggered by the policy instruments will also be monitored respectively.

Performance of mitigation options will be evaluated *ex-post* (i.e. after implementation), either measured directly as *GHG emission reductions*, or measured as *NAMA GHG emissions* in which case the measured GHG emissions will be deducted from those of the BAU scenario. Therefore the monitoring must be compatible with the *ex-ante* projections of the BAU scenario and of the GHG emissions under NAMA implementation (NAMA scenario).

Measurement of co-benefits will be done for those indicators that can be assessed quantitatively on the level of the mitigation options. This is likely to be the case for local air, water and soil pollutants (and compliance with national environmental standards), economic indicators, fertilizer production and the number of skilled jobs provided (see Table 55 for more detail).

2. Prioritized policies

The prioritized policies for the SWM sector with an indirect mitigation impact through fostering mitigation technologies will be MRVed applying the "Causal impact chain" model ("Wirkungskettenmodell"), as recommended in GIZ (2013) and in line with the GIZ-established methodology of "Capacity Works". The first step consists of identifying all potential GHG mitigation and sustainable development benefits mobilized by each of the policy instruments (usually regulatory and fiscal policy instruments) of the NAMA, and then indicate the interrelation among them. The sustainable development benefits (reflected in the NAMA selection criteria – see Section 3.3), i.e. the economic, social and environmental co-benefits of policy implementation will also be MRVed applying the "causal impact chain" model.

3. NAMA support

For the supported elements of the NAMA the external support in terms of financing, capacity building, technical assistance, technology transfer etc. will have to be monitored, along with its impacts where again the "causal impact chain" model will be applied.

Identification of monitoring parameters

For the mitigation technologies the CDM had provided robust MRV systems with stringent verification practices. These well-established and optimized CDM methodologies (UNFCCC, 2015a) should be used as a *basis*, whenever possible and applicable, for the NAMA´s MRV system. However, they require substantial investments in measurement equipment as well as human capacity to collect and process data. Independent verification has proven to be challenging under the CDM due to visible failures in uncovering problems as well as high costs. Frequent complaints of CDM project developers about the high transaction costs of the CDM MRV as well as about procedural aspects such as verification, indicate that simplification in the NAMA context will be necessary.

The NAMA MRV system must allow more flexibility than the CDM approaches, in order to assure its technical, institutional and financial feasibility, and cost-effectiveness. This will be achieved by a reduced set of parameters and/or simplified procedures. The following table lists key available CDM methodologies and some of the parameters to monitor for the selected technologies (see also UNFCCC 2015a):

Table 54: Key parameters for monitoring under CDM methodologies[23]

Methodology	Mitigation options covered	Parameters
ACM 0022: Alternative waste treatment processes (UNFCCC, 2014b)	CH_4 emissions due to anaerobic decay of organic waste are avoided by alternative waste treatment processes.	RDF produced (annually). Volume and NCV of RDF exported (weekly). Volume and NCV of upgraded biogas (continuously). Waste incinerated (continuously). Stack gas flow rate and concentration of N_2O and CH_4 (quarterly). Waste composition on wet basis (3 samples every 3 months). Electricity generation and consumption (continuously). Fossil fuel consumption (annually). Heat generation (monthly). Wastewater treated and its COD (monthly)
AMS-III.F: Avoidance of methane emissions through composting (UNFCCC, 2012a)	Controlled biological treatment of biomass or other organic matter is introduced through aerobic treatment by composting and proper soil application of the compost.	Total quantity of waste composted (monthly). Waste composition on wet basis (3 samples every 3 months). Landfill depth and height of water table (monthly).
ACM 0001: Flaring or use of landfill gas (UNFCCC, 2013)	Capture of landfill gas (LFG) and its flaring and/or use to produce energy and/or use to supply consumers through natural gas distribution network or trucks.	Temperature of flare, existence of flame, generation of products (hourly). Electricity generation and consumption (continuously).
AMS-III.G: Landfill methane recovery (UNFCCC, 2014c)	Capture and combustion of methane from landfills used for disposal of residues from human activities including municipal, industrial and other solid wastes containing biodegradable organic matter.	LFG destroyed, its methane content, pressure and temperature (continuously). Electricity generation.
Methodological Tool: "Emissions from solid waste disposal sites" (UNFCCC, 2012c)	Designated areas intended as the final storage place for solid waste. Stockpiles are considered a SWDS if (a) their volume to surface area ratio is 1.5 or larger and if (b) a visual inspection by the DOE confirms that the material is exposed to anaerobic conditions (i.e. it has a low porosity and is moist).	Total wet waste (annually). Waste composition on wet basis (3 samples every 3 months). Landfill depth and height of water table (monthly).
AMS-III. AJ: Recovery and recycling of materials from solid wastes(UNFCCC, 2012b)	Recycling of materials in MSW to process them into intermediate or finished products, that is plastic resin to displace the production of virgin plastic materials in dedicated facilities, thereby resulting in energy savings. CH_4 emissions due to avoided anaerobic decay of paper and cardboard.	Total volume of MSW (annually). Recycled fractions sold (weighed, invoices per batch). Electricity and fossil fuel consumption (continuously). Intrinsic viscosity (per batch)
AMS-III.E: Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment (UNFCCC, 2014d)	Decay of the wastes that would have been left to decay or are already deposited in a waste disposal site is prevented through controlled combustion; or gasification to produce syngas/producer gas; or mechanical/ thermal treatment to produce refuse-derived fuel (RDF) or stabilized biomass (SB).	Waste combusted, gasified or mechanically/thermally treated (annually). Waste composition (representative sampling). Auxiliary fuel used. Non-biomass carbon content of the waste or RDF/ SB combusted (representative sampling). Ash volume. Average truck capacity. Electricity consumption and generation. Distance for transporting the waste in the baseline and the project scenario and the distance for transporting the produced RDF/SB.

23 Further waste-specific methodologies include AM 0083 "Avoidance of landfill gas emissions by in-situ aeration of landfills", AM 0093 "Avoidance of landfill gas emissions by passive aeration of landfills", AMS-III.AF "Avoidance of methane emissions through excavating and composting of partially decayed municipal solid waste (MSW)", AMS-III.L. "Avoidance of methane production from biomass decay through controlled pyrolysis"

The identified NAMA selection criteria (see Section 3.3) provide parameters of which a sub-set should be monitored, particularly for the MRV of the sustainable development benefits (economic, social and environmental co-benefits) of technology and policy implementation.

Table 55: MRV of sustainable development co-benefit indicators

No.	Criterion	Parameters
I.B	Abatement cost	Average abatement cost of mitigation options under the NAMA (every 5 years)
II.A	Maturity of technologies	Number of projects globally using the technologies over the last 5 years (databases of Aid Data, CDM; every 5 years)
II.C	Transfer of technology	Absence of the technology from India (annually)
II.D	Use of indigenous technology	Share of mitigation options produced domestically (%, every 5 years)
II.E	Ease of implementation	Share of mitigation options implemented in India before the start of the NAMA (%, every 5 years)
III.A	Bankability	NPV (once at start of each mitigation option implementation), average IRR of all projects under the NAMA (every 5 years)
III.B	Leverage of private sector finance	Share of private finance in total financing for the sum of all mitigation options implemented (every 5 years)
III.C	Improved balance of payments	Change of foreign exchange demand (annually)
III.E	Efficient utilization of resources	Land use (ha), energy use (electricity/heat/fuel), water use (m^3) (annually)
III.F	Markets	Prices for each product (annual average)
III.G	Job creation – direct	Number of people employed (annual average)
IV.A	Formalization of unorganized sector	Number of people employed in skilled jobs (annual average)
V.A	Impact on air	Compliance with CPCB/SPCB standards (annually)
V.B	Impact on water	Compliance with CPCB/SPCB standards (annually)
V.C	Improvement in soil fertility	Volume of fertilizer production (annually)
V.D	Impact on noise pollution	Compliance with CPCB/SPCB standards (annually)

Other aspects of the NAMA´s MRV approach

The **institutional set-up of the MRV system**, including definition of processes, communications, reporting formats etc., must consider the capacities of the institutions involved (see Section 9.2.). Capacity building needs at different levels shall be defined prior to NAMA implementation. A close collaboration among all the various stakeholders of the NAMA shall be established, along with clear responsibilities.

The SWM NAMA´s MRV approach shall follow the same principles and formats across the several NAMA´s under development by GoI. However, general NAMA guidelines have not yet been established by the authorities.

On the other hand, it will be important that the MRV system is **compatible with the national MRV approach** in order to be included as part of the country´s Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC).

Furthermore, the system shall build as far as possible on existing MRV mechanisms in the SWM sector, such as reporting obligations to State or Central Pollution Control Boards. However, these reports usually do not provide the necessary level of detail as needed for NAMA MRV.

Finally, for any supported element of the NAMA, the predesigned MRV system will have to be adapted to the **requirements of the potential donors or supporters**, to be able to monitor their goals of NAMA support and satisfy their required level of data robustness and completeness.

8.3 DATA GAPS

As shown in Section 2, there are significant gaps in data on population, waste composition, waste collection rates, especially in small municipalities, and characteristics of SWDS, amongst others.

Although the MSW Rules 2000 were first notified in the year 2000, thrust has never been in carrying out waste quantification and composition analysis by the ULBs. The National Environmental Engineering Institute (NEERI) has carried out extensive studies on characterizing of solid waste from 43 cities during 1970-1994 (CPHEEO, 2000). The data from these studies has formed the background material for the MSW manual of MoUD and CPHEEO (2000). The study gives inputs on the per capita waste generation classified on population, physical and chemical characteristics of MSW of Indian cities. MoUD and CPHEEO (2000), recognise that waste is subject to seasonal variation and socio economic criteria. It also emphasises that no rational decision on MSW system can be made until the data on composition and quantity is known. Yet in the year 2015, a substantial part of Indian cities do not have access to the compositional data of their waste.

The following limitations remain:

1. **Limitation of population projection**

   Some of the limitations complicating past, current and future population estimates are: The data on population is not updated annually; the census information is obtained every ten years; the coding of cities is not consistent with previous years, also the ward names/ cities names are spelt differently during ward delimitation exercise. In many cases, the name changes of cities or adding of urban agglomeration or bifurcation/ trifurcation results in erroneous population projections. Many new cities do not have historical trends, especially those that are in the process of urbanisation. For Example: The “North and Middle Andamans“ district (code 35639) and the “South Andaman“ district (code 35640) has been carved out in 2011 from Andaman district (code 350) of 2001. Thus historical data would not be available for analysis. Similarly, the State Telangana has been formed post 2011 and carved out of the former state of Andhra Pradesh (State code 28). This implies that although the recommendation of the MDDS (Meta Data & Data Standards) Committee has been adopted to frame the Place Code, it is difficult to compute the annual exponential growth rate of population based on past decadal census data.

2. **Limitations of waste generation rate estimation**

   Primary studies of waste generation at city levels are scarce. Waste is not weighed at source (e.g. household) or at ward level. Usually, the assessment is based on “rule of thumb“ such as population multiplied by per capita generation for cities with similar population or average payload of waste transport vehicles multiplied by number of vehicles. This usually gives a higher estimate of waste generation from cities. Also, wherever primary data has been captured at household or source level, the data does not capture the amount of waste that is usually “lost“ or not captured due to stray animals or materials that are picked by the informal sector. Some of the defined city groups do not have enough accessible waste generation studies (not enough accessible waste studies).

   The Directorate of Municipal Administration (DMA) receives information from the individual ULBS and compiles the same and furnishes it to the State Pollution Control Board. The typical information format includes name of ULB, population and households, total waste generated, waste collected and waste treated, windrow composting and whether SLF constructed or not.

The per capita generation in these reports are not based on any studies but are inferred from nominal capita generation from NEERI studies.

3. **Limitations of waste composition estimation**

   MoUD and CPHEEO (2000) have explained the process of sampling and conducting analysis and also made it clear that it is very important for decision making on MSW system. Therefore, waste composition in typical DPRs is obtained by carrying out short studies ranging from a week to a fortnight. As the DPRs are focused on selecting the right technology the thrust is on identifying biodegradables, inerts, recyclables, metals, moisture content etc. However, the biodegradables that form the bulk are not usually analysed further, which renders the GHG estimations difficult. The composition of waste changes considerably with geography, cultural and food habits which are not captured.

   As stated earlier, the studies refer to "composition at generation point (households)", and it is likely that in India over-proportionally recyclables but also organic matter do not reach the disposal site. Hence, the utilized composition data should be confirmed with actual composition data at disposal site. The data furnished to the State and Central authorities do not have the composition data as it has not been mandated.

   Even during operations of the MSW processing plant, these data are not captured as it is not obligatory for the service providers to report the same. Of late, there are few PPP contracts which mandate the report of the composition failing which a penalty is levied on the service provider.

4. **Limitations of DOC estimation**

   Traditional reports and analysis are oriented towards project selection, DOC were never studied. Expectedly, DOC may see wide variation among Indian cities. Hence actual study results, when available, should be used for DOC data.

5. **Limitations of DOCf estimation**

   The DOCf value is dependent on many factors like temperature, moisture, pH, composition of waste, operation of dumpsite etc. which varies across India. A default IPCC value is applicable under the assumption that the SWDS environment is anaerobic and the DOC values include lignin which is true in most large cities with less access to landfill areas. However, in the case of smaller towns, this assumption is not true as many SWDS sites are low height and aerobic in nature. This is generally caused due to the fact that these small towns do not have material handling equipment and rely on tipper spreading at the dumpsite. Again, the conditions used for estimation are based on the ideal design. In reality, the operation of the SWDS determines whether the site is anaerobic or unmanaged. The actual variation in these parameters may have impact on actual DOCf value.

6. **Limitations of MCF estimation**

   The data needed for estimating MCF value for each city group is not available, therefore MCF is not validated from actual data. For the future it is recommended to estimate MCF for a limited sample within each city group based on actual site visits.

   Waste disposal practices within a city or city group change with time. However the impact of the same has not been considered in this analysis.

   A number of cities will change the city group in future and this also will impact on their waste disposal practice. However the same has not been considered in the present analysis.

7. **Limitations of Fraction of CH4 in Generated Landfill Gas**

   The MSW rules prohibit the deposition of organics/ biodegradable into sanitary landfills. However, due to operational inefficiencies, lack of market for compost and lack of plant capacity, a large fraction enters the disposal sites which causes methane emissions and naturally affects landfill gas composition. The methane fraction can be more than 50% in case there is significant amount of fat or oil present in the solid waste, primarily as residues from oil and grease traps are usually disposed with MSW.

Furthermore it can be stated that important data gaps remain regarding:

- Monitoring of basically all waste flows,
- which of the registered waste plants work and with which real capacity,
- new or planned waste projects, and
- waste management practices and possible GHG emissions in small cities (<20k) and rural areas.

Furthermore, most of the parameters of sustainable development and co-benefits are currently not systematically monitored.

8.4 KEY ASPECTS OF SECOND BEST MRV SYSTEM GIVEN DATA AVAILABILITY IN INDIA

A second best MRV system could be based on conservative default values for baseline emission parameters, such as MCF and the organic share of waste reaching the treatment plants. Likewise, for mitigation technology performance, default parameters could be envisaged as well.

As stated in the earlier Section, the current level of reporting envisages capturing only waste generated, collected and processed. However, ULB specific data on waste generation, waste composition and the amount of waste landfilled can be captured with a small initiative from the State/ Pollution control board. The method of sampling, analyzing and reporting is already available in the MSW manual. Few pilot studies carried out by Ecoparadigm/GIZ have helped develop capacities in ULB like Simla, Manali, Tirupati in acquiring this data and proving that the task is "doable" and capacities can be built up at short notice and minimum cost.

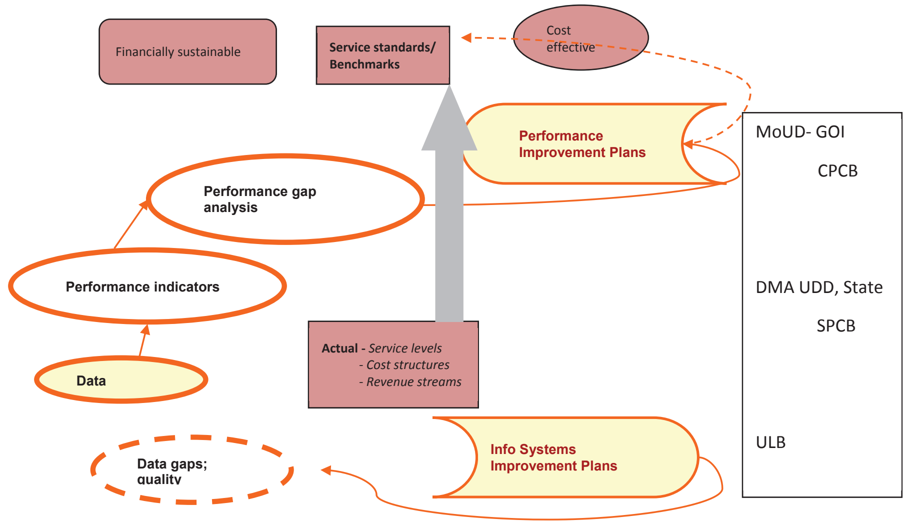
Certain states like Karnataka, have taken a decision to employ at least one environmental engineer for solid waste management at the ULB level. This system could be replicated at all ULBs in the country. These environmental engineers could be called on to carry out audits of ULB at the ward level. Further at the State, the SPCB could be mandated to conduct audits at the ULB level. This would entail deploying additional manpower and resources and deciding on the periodicity of such audits. The SPCB laboratory which exists at regional level in all states can be authorized to carry out such exercise. Private sector labs which are authorized by SPCB for water and wastewater currently can also be encouraged and authorized to carry out this MSW quantification and Composition analysis. Similarly the PPP operators can be mandated by SPCB to report the monthly composition and quantification as well as the organic content in landfill as part of the annual Environmental statement of the annual returns filed in the month of October every year. This condition can be imposed by the SPCB in the Consent for Operation of the MSW plant or the MSW authorization procedures.

Service level benchmarks (SLBs):

There has been a realization that substantial investments were made in urban sector with little clarity of whether they were yielding results due to lack of information database. The move towards decentralization (74th amendment) requires the ULB to be accountable for service delivery. This means that one should be able to track the performance over time and also be able to compare to peers to identify best practice. The SLBs help to meet the growing pressure for public disclosures and greater transparency on performance.

All the urban local bodies have been mandated to report the SLBs as stipulated by the MoUD to the 14th Finance Commission and further funds are made conditional to reporting the data of performance (Finance Commission, 2013).

Figure 36: Objective of the Service Level Benchmarking of MoUD (ASCI, 2010)



The SWM has 8 indicators under MoUD's SLBs as per below table:

Table 56: Indicators, benchmarks, monitoring and reporting standards for SLBs (hierarchy of reporting from left to right; MoUD, no date c)

Urban Service	Frequency of Measure- ment by ULB/Utility	Frequency of Report- ing within ULB/ Utility	Frequency of Report- ing to State/ Central Govt.	Jurisdiction for Measure- ment by ULB/Utility	Jurisdiction for Report- ing within ULB/Utility	Jurisdiction for Report- ing to State/ Central Govt.	Benchmark
1. Household level coverage of SWM services	Quarterly	Quarterly	Annually	Ward	Ward	ULB	100%
2. Efficiency of collection of municipal solid waste	Monthly	Monthly	Annually	Ward	Ward	ULB	100%
3. Extent of segregation of municipal solid waste	Monthly	Monthly	Annually	ULB	ULB	ULB	100%
4. Extent of municipal solid waste recovered	Monthly	Monthly	Annually	ULB	ULB	ULB	80%
5. Extent of scientific disposal of municipal solid waste	Monthly	Monthly	Annually	ULB	ULB	ULB	100%
6. Efficiency in redressal (addressing) of customer complaints	Monthly	Monthly	Annually	Ward	Ward	ULB	80%
7. Extent of cost recovery in SWM services	Annually	Annually	Annually	ULB	ULB	ULB	100%
8. Efficiency in collection of SWM-related charges	Annually	Annually	Annually	Ward	Ward	ULB	100%

The table shows the frequency of measurement of attributes, reporting to the higher level of organization at State and Central level and the unit level of measurement at various levels. The desired benchmark stipulated by the MoUD is also depicted.

The data reliability for each of the attributes is tabulated below (MoUD, no date c). As seen, each attribute has a different reliability based on the quality of data. It is envisaged that the cities would progressively move from low reliability to the highest reliability over time. The SLBs are monitored by the ULB and reported to the Urban Development Department (UDD) of the State which in turn collates information from all the ULBs and forward to the Ministry of Urban Development (MoUD) at the centre.

Household level coverage of SWM services (door-to-door collection)

fgsd

Table 57: SLB attribute reliability

1. Household level coverage of SWM services (door-to-door collection)	
Assessment methodology	Reliability class
• Actual no. of household & establishment with door-to-door service – verified from user charge records • Actual no. of household & establishment – measured through GIS spatial planning	A – High
• Quantity of waste collected from areas serviced by D-T-D service • Total waste generation • Daily average from actual weight – consecutive 7 days	B- Intermediate
• No. of wards/ zones serviced by D-T-D service • Total no. of wards/ zones	C- Intermediate
• Aggregate city level estimates provided by ULB	D- Low
2. Efficiency of collection of Municipal Solid waste	
Assessment methodology	Reliability class
• Waste Generation based on sample survey • Waste collection – actual weight of waste at disposal & processing facility	A-High
• Waste Generation – empirical per capita generation formula • Waste collection – actual weight of waste at disposal & processing facility	B-Intermediate
• Waste Generation – empirical per capita generation formula • Waste collection – no. trips by collection vehicles	C-Low
3. Extent of segregation of municipal solid waste	
Assessment methodology	Reliability class
• Segregated waste received at disposal/ processing sites – measured regularly • Quantum of waste taken away by recyclers from intermediate points	A – High
• Quantity based on inputs from agencies involved in D-T-D service	B- Intermediate
• Households & Establishment provided with two-bins	C- Intermediate
• Segregation Estimates provided by ULB without any documents/ measurements	D- Low
4. Extent of Municipal Solid waste recovered	
Assessment methodology	Reliability class
• Quantity inputs at processing facilities • Quantity – Community Level Composting • Recycling – Intermediate point	A – High
• Quantity inputs at processing facilities only	B- Intermediate

•	Mass Balance – Total generation less disposal	C- Intermediate
•	Installed capacity of processing facilities	D- Low
5.	Extent of Scientific disposal of municipal solid waste	
Assessment methodology		Reliability class
•	Accurate data – waste received at compliant & open dumpsites – weighbridge data	A – High
•	Record maintained at landfill sites	B- Intermediate
•	Mass Balance – Total generated less processed & recycled	C- Intermediate
•	Estimates based on no. trips by collection vehicles	D- Low
6.	Efficiency of redressal of customer complaints	
Assessment methodology		Reliability class
•	Multiple mechanism for registering • Computerized based system • Complaints collated through computer network & tracked daily	A – High
•	Multiple mechanism for registering • No computerized based system • Manual record	B- Intermediate
•	Multiple mechanism for registering • No records – assumed all complaints are redressed in 24 hrs.	C- Intermediate
•	No data maintained	D- Low
7.	Extent of cost recovery in SWM services	
Assessment methodology		Reliability class
•	Budget heads of SWM clearly separated and cost allocation standards for common costs are in place. • Accrual based double entry accounting • Accounting standards comparable to commercial accounting standards with clear guidelines for recognition of income and expenditure are followed • Accounting and budgeting manuals are in place. • Full disclosure and auditing timely and regular	A – High
•	Budget heads of SWM segregated, key costs identifiable, Accrual based accounting • Disclosure complete and timely, accounts finalized and closed, audit may be pending	B- Intermediate
•	Not applicable	C-Intermediate
•	Cash based accounting • No function wise accounting, difficult to estimate SWM related establishment, administrative and O & M costs. Disclosure and reporting not timely	D- Low
8.	Efficiency of collection of SWM charges	
Assessment methodology		Reliability class
•	Accrual based accounting • Proper segregation of SWM related expense & revenue • Records maintained for each billing cycle	A – High
•	Accrual based accounting • Key SWM related expense, revenue & arrears segregated	B- Intermediate
•	Not applicable	C- Intermediate
•	Cash based accounting • No segregation of SWM related expense, revenue & arrears	D- Low

A sample of the SLB of solid waste reported by the Municipal Corporation of Simla to the 13th Finance commission is shown below (Finance commission India, 2013). It can be seen that ULBs indicate a desirable target for the next year.

Table 58: Sample SLB of solid waste reported (Finance Commission India; 2013)

		Benchmarks	
Household level coverage of solid waste management services	100%	Current (2010 – 11)	84.8
		Targets (2011 – 12)	90
Efficiency of collection of municipal solid waste	100%	Current (2010 – 11)	77.8
		Targets (2011 – 12)	80
Extent of segregation of municipal solid waste	100%	Current (2010 – 11)	10
		Targets (2011 – 12)	20
Extent of municipal solid waste recovered	80%	Current (2010 – 11)	15
		Targets (2011 – 12)	30
Extent of scientific disposal of municipal solid waste	100%	Current (2010 – 11)	0
		Targets (2011 – 12)	50
Extent of cost recovery in SWM services	100%	Current (2010 – 11)	9.9
		Targets (2011 – 12)	15
Efficiency in collection of SWM charges	90%	Current (2010 – 11)	44.4
		Targets (2011 – 12)	60
Efficiency in redressal of customer complaints	80%	Current (2010 – 11)	74.1
		Targets (2011 – 12)	80

At present, all the ULBs are compiling this information and reporting to the respective UDD of the state. Some states have provided training on SLBs to their existing staff, however, the capacities are still lacking. The trainings are provided by NGOs, development agencies, and policy research institutions. The measurements of the attributes are acquired by the ULBs either from its own staff or from its outsourced contractors or PPP partners who are obligated to report. Currently, almost all ULBs report information based on the Reliability data class D. The information is also not verified at present and consequently, several inconsistencies can be noticed during compilation. Also the SLBs are currently oriented towards compliance of the MSW rules. The availability and extent of funding for the ULBs are conditional to the achievement and progress in SLBs.

In the absence of an ideal MRV system, the SLBs with data of reliability class A would serve as the next best system for NAMA and with a small modification on the data template can serve to enhance the utility of SLBs towards MRV in NAMA. The key attributes that are relevant are:

1. Household level coverage of MSW services: At class A reliability, GIS based data and actual door- to-door collected.
2. Efficiency of collection of MSW at class A reliability, this shall mean a regular sample survey at collection and actual weighting of waste at processing and disposal facility.
3. Extent of segregation of MSW at class A reliability, waste composition can be obtained as prescribed in the MSW manual. Additional information needed can be solicited by amending the format for collecting input data for this attribute.
4. Extent of Municipal solid waste recovered at class A reliability, the material balance of MSW composition and products produced is useful to estimate the net GHG produced
5. Extent of scientific disposal of MSW: Again, the quantum of waste disposed in SLF and the actual organics present would lead to better estimates such as MCF and DOC

Apart from the SLBs, the following are relevant:

1. Consent for operation (MSW authorization) which indicates the condition for operation, emission standards and periodicity of measurement can serve as alternate MRV system.
2. The Environmental Statement submitted annually can be another tool for reporting performance of processing plant and SLF if appropriate changes in template are made. Since this is an obligatory function of all operators, the SPCB can monitor the performance.
3. The DPR format suggested by MoUD can be modified to include projections of GHG emission which can then be monitored by the SPCB and DMA (MoUD, no date a).
4. National Urban Data Base Indicators Proforma for Data Collection at Town or Ward Level of the MoUD can be utilized to collate the data captured above and make it available for further analysis (MoUD, no date b).

Elements of a SWM NAMA in India

9

Elements for the design of a SWM NAMA in India can be classified as follows – mitigation options, regulatory policy instruments, fiscal policy instruments and capacity building elements (see Section 4). Many options for a SWM NAMA in India (called "NAMA options" in the subsequent text) can be derived from different combinations of these elements. Eventually, the SWM NAMA can consist of one or several of these options.

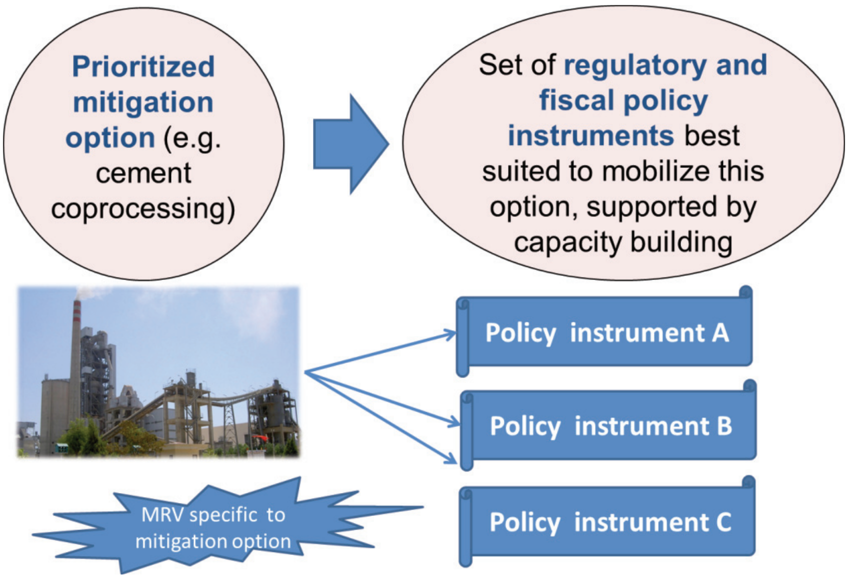
There can be two approaches to designing a NAMA option. In one approach, the design of a NAMA option starts from the mitigation option whereas in another approach, the design of NAMA option is driven by policy/fiscal instrument supported by capacity building elements.

Approach 1: Starting from the Mitigation Option

In this approach, one selects from the list of prioritized mitigation options supported by suitable regulatory policy & fiscal policy instruments and capacity building elements to result into a concrete and complete NAMA option which is able to overcome the challenges and barriers faced by the sector discussed in Section 4.3.

An example to illustrate the same is depicted in Figure 37 where *RDF from MSW for co-processing in cement industry* is a prioritized mitigation option from which the design of a NAMA option commences. For effective implementation of the mitigation option appropriate regulatory & fiscal policy instruments and capacity building elements are required to develop a full-fledged NAMA option. For example, currently there are no guidelines on inter-state transfer of waste destined for co-processing and thus such transfers do not take place. Introduction of a guideline would remove this barrier. The lack of economic attractiveness of RDF plants could be overcome by an output based incentive such as a tipping fee for municipal waste treated. Capacity building would complement the policy instruments, e.g. in form of a centralized R&D facility that proves suitability of new types of waste for co-processing.

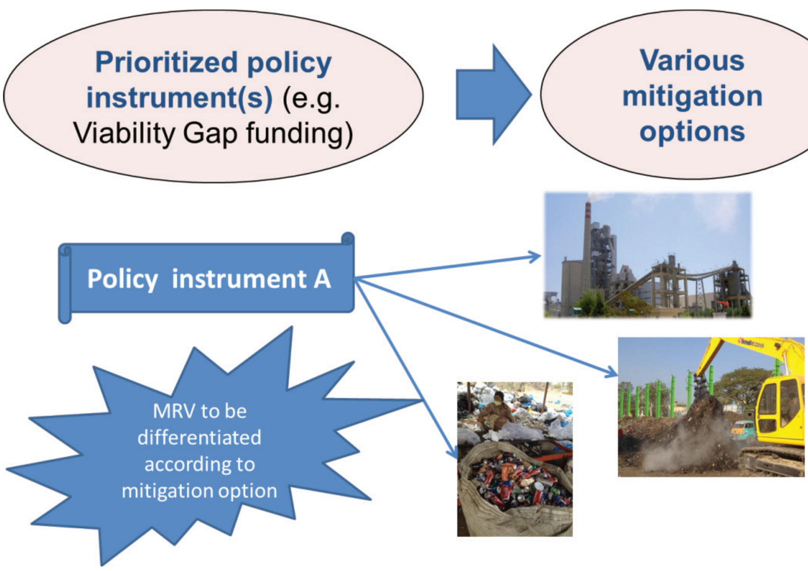
Figure 37: Defining NAMA options: 1) Starting from the mitigation option



Approach 2: Starting from the Policy Instruments

In this approach, one selects one or a combination of policy instruments that then can drive many different mitigation options. An example is depicted in Figure 38 where *Viability Gap Funding (VGF)* is the prioritized fiscal policy option. This fiscal policy instrument can drive many mitigation options. Other regulatory policy instruments and capacity building elements are differentiated as per the targeted mitigation option(s).

Figure 38: Defining NAMA options: 1) Starting from the policy instruments



9.1 NAMA OPTIONS IN THE SWM SECTOR

As discussed in Section 7, the mitigation options RDF from MSW for co-processing in the cement industry, composting and vermicomposting, and biomethanation should be prioritized. Section 7.4 proposed regulatory and fiscal policy instruments that should drive these mitigation options. In order to develop full-fledged mitigation-option driven NAMA options, we complement this with capacity building activities (see tables below).

Table 59: NAMA option RDF from MSW for co-processing in cement industry

Priority	Regulatory policy instruments	Fiscal policy instruments	Capacity building
1	Guidelines allowing inter-state transfer of waste in case of co-processing of waste	Output based incentive through tipping fee for municipal waste treated	Centralized R&D facility that proves suitability of new types of waste for co-processing
2	Definition of waste types applicable for all states	Viability Gap Fund	Capacity building regarding MRV (data collection, management, QA/QC)
3	Guidelines for pre-processing of waste in cement industry	Revolving Loan Fund	

Table 60: NAMA option Composting and vermicomposting

Priority	Regulatory policy instruments	Fiscal policy instruments	Capacity building
1	Facilitation of land identification & acquisition	Viability Gap Fund	Training of auditors to check quality standards
2	Quality standards and label for compost	Government-specified price for purchase of compost	Capacity building of informal sector
3	Uptake requirement of unsold compost by forest / agricultural department	Output based incentive through tipping fee for municipal waste treated	Training of vermicomposting operators

Table 61: NAMA option Biomethanation

Priority	Regulatory policy instruments	Fiscal policy instruments	Capacity building
1	Enforcement of mandatory segregation of waste at household level	Output based incentive through tipping fee for municipal waste treated	Training of operators
2	Facilitation of land identification & acquisition	Viability Gap Fund	Research and development for "unusual" waste
3		Feed in tariff for electricity	

We propose two policy instrument-driven NAMA options. The first option "Waste treatment incentives with technology-differentiated results-based payments" consists of a combination of the following three policy instruments

- Single window clearance for waste management projects
- Output based incentive through tipping fee for municipal waste treated
- Viability Gap Fund differentiated by mitigation option

This NAMA option would provide strong incentives for private sector involvement as waste treatment would generate revenues. It would require political will to provide the budget for such policy instruments, but could be implemented relatively quickly once budget allocation is provided.

The second option "Enforcement of mandatory segregation of waste" would be based on two regulatory policy instruments:

- Enforcement of mandatory segregation of waste across the whole chain
- Facilitation of land identification & acquisition

This NAMA option would not directly incentivize mitigation options but provide the necessary conditions for mitigation options on the higher ranks of the waste hierarchy. Given the past challenges to enforce the MSW rules, it would require a high level of political engagement and willingness of central government to interact with states and ULBs in order to identify non-compliance and its remediation. This would probably only emerge in the long run.

In order to prioritize among the five NAMA options outlined above that all have scored highly on the set of C&I developed in Section 3, we assess them according to key feasibility criteria - MRVability, feasibility of replication/scale up, institutional readiness, readiness with regards to policy/regulations and existence of markets for by-products (see Table 62).

In the case of co-processing in the cement industry, the cement industry is highly sophisticated and has past CDM experience, so should not face significant problems to implement MRV. As it is highly organized, replication of projects is likely to be rapid. Cement plants and the CMA are quite well prepared, but the policy readiness to support the technology remains to be improved. Cement markets are well-developed.

Composting faces the challenge of aggregation of data. Replication is easy but the size of projects is relatively small. Only few ULBs have shown their ability to sustain composting over the long run. Policy instruments to support composting are so far limited and do not work properly. Markets for compost are fragmented and trust in compost quality is low.

Biomethanation requires relatively complex MRV for which the operators are not prepared. Scale-up strongly depends on whether waste segregation is achieved. Institutional and policy readiness are comparable to composting. Due to varying quality of gas, markets are not well developed.

Fiscal incentives can mobilize many technologies whose MRVability differs considerably. They can trigger rapid replication and scale-up of projects as shown in the Indian renewable energy sector. Institutional experience on central and state government level with management of fiscal incentives is thus quite good. So far however policy and regulatory readiness in the waste sector is limited to few, isolated initiatives. Fiscal incentives can be designed in a manner to improve the marketability of by-products but this needs special attention.

Mandatory segregation is comparable to the fiscal incentives regarding the MRVability. There is however no experience of sustained success of mandatory segregation that leads to scale-up of technologies. Institutional and policy/regulatory readiness is low. As segregation would improve the quality of compost and biogas, it would increase trust in product quality.

Table 62: Prioritization of NAMA options according to feasibility and readiness criteria

Option	MRVability	Feasibility of replication/scale up	Readiness -institutional	Readiness - policy/ regulations	Readiness - markets for by-products
RDF from MSE for co-processing in cement plants	+	+	o	o	+
Composting	0	o	-	-	-
Bio-methanation	-	o	-	-	-
Fiscal incentives	Depends	+	o	-	depends
Enforcement of segregation	Depends	o	-	-	+

Note: +: high, o: medium, -: low

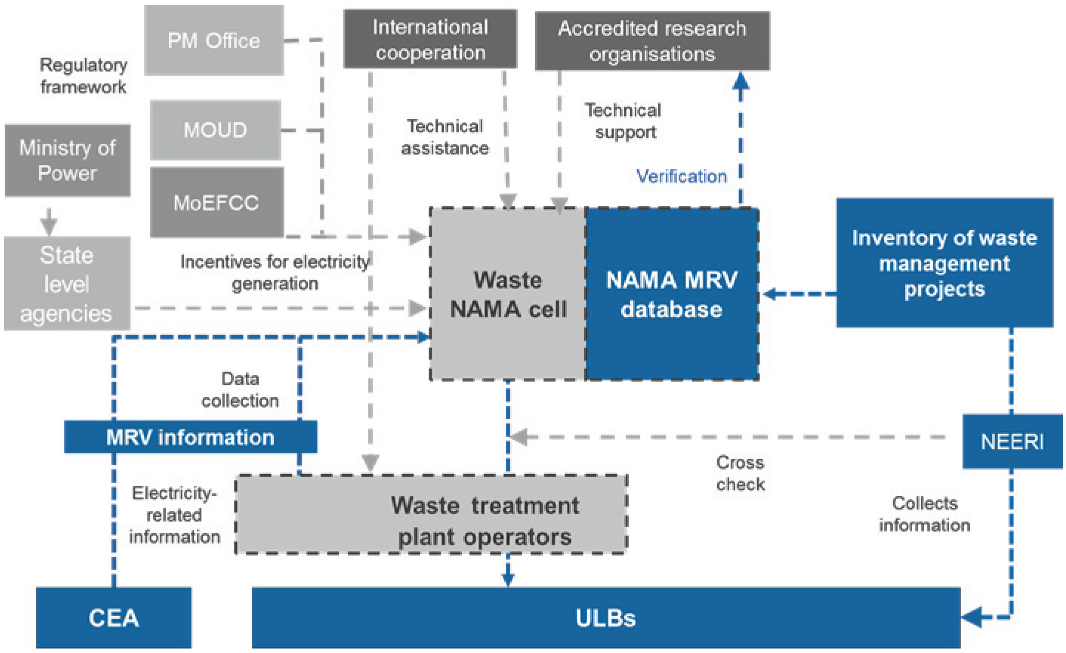
The overall score of the assessed NAMA options shows that co-processing in cement plants and fiscal incentives are the two most promising NAMA options. The former option can be implemented relatively quickly, whereas the latter will take more time. It should be noted that this assessment is preliminary and needs to be deepened before the SWM NAMA is designed in detail.

9.2 INSTITUTIONS MANAGING THE NAMA

The SWM NAMA management needs to take into account the multi-layer structure of MSW management in India. MoEFCC is naturally placed to be the agency that should be responsible for setting up a "Waste NAMA cell". This cell should consist of staff seconded from MoEFCC and MOUD, and coordinate outreach to receive technical assistance from international sources. It should also interact with the PM office and be responsible for managing the MRV database. It should decide on default emission factors for the baseline and the NAMA case. A roundtable of waste management companies and NGOs would consult the NAMA cell. The NAMA cell should set up a help desk for ULBs wanting to improve their SWM.

State level power regulatory agencies should provide data on incentives for electricity production from waste. The CEA should provide the baseline data for the electricity grid, whereas a research institution like NEERI could be tasked to set up an inventory of MSW management projects, collecting information from ULBs. At the same time, waste treatment plant operators would provide information regarding waste volumes treated and the technology implemented, as well as information on the sustainable development indicators to the waste NAMA cell (like CDM project developers provide information to the National CDM Authority). The information would be aggregated in the MRV database. NEERI would cross-check it with the information collected from the ULBs. The cross-checked data would regularly be made available to accredited research organizations, some of which would provide technical support whereas others would check the information in the database and verify its correctness.

Figure 39: Institutional approach to the SWM NAMA



9.3 THE MRV SYSTEM

MRV should be differentiated – NAMA options that harness international financing or carbon market revenues should in general follow the CDM methodologies for the specific technologies involved, applying direct measurement of key parameters.

All other NAMA components should be benchmarked with regards to a baseline emissions intensity per t of waste generated. For each treatment option, an emissions intensity per t waste treated would be specified that is based on conservative assumptions. Treatment plants should be enabled to opt for a "CDM type" MRV if they are of the opinion that the benchmark approach is too strict.

The following table describes a preliminary proposal for the NAMA´s MRV system with four interconnected fields of monitoring: "Prioritized SWM mitigation options", "Prioritized policies", "Sustainable development benefits" and "NAMA Support":

Table 63: Proposal of MRV system

Field of Monitoring	Method	Parameters to be monitored	Institutions involved
Prioritized SWM mitigation options	CDM methodologies approved for the respective mitigation option (see Section 8.2, Table 54), adapted if necessary The systems rigidness will depend on support mechanisms; e.g. higher for mitigation options fostered by "result-based financing" and / or for internationally supported mitigation options	Parameters indicated by respective CDM methodologies, adapted if necessary (see Section 8.2, Table 54) Sustainability indicvators - Direct impact: a subset of the indicators named in Section 8.2, Table 55 e.g. no. of employments created through new composting plants e.g. generated renewable energy (MWh/a) Indirect impact: difficult to measure	Monitoring and reporting: ULBs and plant operators Data compilation: SPCB Verification: NEERI and accredited institutions Coordination: Waste NAMA cell
Prioritized policies	Causal impact chain model	Inputs / activities: e.g. technical assistance for adapted legislation Outputs: e.g. proposal of adapted legislation Use of outputs: e.g. by political decision makers within legislative process Direct impact: e.g. adapted legislation in force Indirect impact: measurable implementation of mitigation options Sustainability indicvators : a subset of the indicators named in Section 8.2, Table 55	Monitoring and reporting: Coordination: Waste NAMA cell Verification: to be defined
NAMA support	Causal impact chain model	Inputs / activities: e.g. result based financing e.g. capacity building Outputs: e.g. executed trainings Direct impact: e.g. additional quantity of treated waste Indirect impact: GHG mitigation	Monitoring and reporting: Supporting organizations and Waste NAMA cell Data compilation: Waste NAMA cell Verification: to be defined together with supporting organization

The central element of the MRV system is the Waste NAMA cell (see Section 9.2), responsible for managing the MRV database, coordinating technical assistance related to MRV, and with a help desk for ULBs and plant operators which can support also in in monitoring and reporting issues.

While waste treatment plant operators and ULBs report to the Waste NAMA Cell, either directly or via SPCB, NEERI as well as other independent research institutions to be accredited for this purpose would verify the reported data. Verification processes should be generally executed by national institutions, except for cases when international supporters require otherwise.

For cost-effectiveness the system shall build as far as possible on existing institutions and existing MRV mechanisms in the SWM sector, such as the Service level benchmarks (SLBs) and the Environmental Statements submitted annually by plant operators with to SPCB (see Section 8.4). However, the existing systems cover only a part of the parameters to be monitored and would have to be extended or complemented accordingly.

Capacity building shall be provided to all MRV involved institutions regarding data collection, reporting, management, and QA/QC procedures prior and during first phase of NAMA implementation.

Conclusions and recommendations regarding a SWM NAMA in India

10

Development of a Nationally Appropriate Mitigation Option (NAMA) requires prioritization of policy instruments - that incentivize mitigation options or remove regulatory barriers - according to agreed criteria and indicators (C&I), building upon existing policies. A key aspect of a NAMA is the ability to monitor, report and verify (MRV) outcomes. MRV of a NAMA can be less cumbersome than for the Clean Development Mechanism (CDM) if the NAMA does not generate credits. NAMAs are not a replication of CDM as they are organized by government and do not target specific projects. This also means that technical support and financing is primarily channeled through multi- and bilateral institutions such as the NAMA Facility and the Green Climate Fund, not through carbon markets. There is a strong competition of NAMA developers around the world for the currently few NAMA financing sources. Waste sector NAMAs are conceptualized in countries of various levels of development around the world but only few of them are sufficiently advanced to reach the implementation stage.

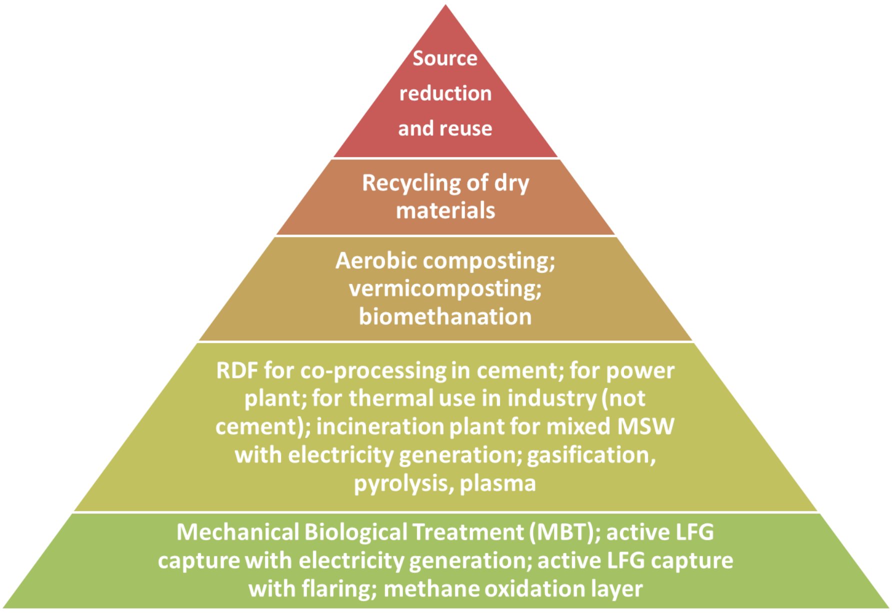
The Indian municipal solid waste management (MSW) sector is principally well suited for NAMA development. There is a wide range of policy instruments introduced by the central and state level that can serve as starting point for a MSW NAMA. Nevertheless, there are significant challenges as only 2/3 of waste are collected and less than a fifth is undergoing specific treatment. Differences between states and municipalities are significant.

In order to assess potential NAMA options which involve waste management technologies as well as regulatory and fiscal policy instruments, criteria and indicators (C&I) are developed to ensure that sustainable development goals of the Government of India are met, mitigation is mobilized and the results are internationally credible and acceptable. Our C&I set takes is based on criteria applied in the approval of CDM projects by the National CDM Authority of India and has been supplemented by C&I from the UNFCCC voluntary sustainable development tool for CDM, the Gold Standard, GIZ's template for NAMA formulation, the Green Climate Fund and the NAMA Facility. The latter wants to ensure that the NAMA is competitive in the international landscape with respect to mitigation cost and financing source-specific C&I. Our C&I cover mitigation potential, and economic, technological, environmental and social benefits, with a total of 30 indicators.

The CDM has triggered some activities in MSW management, but shown relatively low success in issuance of CERs. This is linked to operational problems of the plants as well as a relatively cumbersome MRV process and the fall in the credit price after 2011.

As per the waste hierarchy embodied in the MSW Rules, five layers of technology option can be identified, with a total of 14 technologies.

Figure 40: Mitigation options as per the waste hierarchy



An economic assessment of twelve of these mitigation options generally finds low mitigation costs, with negative mitigation costs for half of the assessed options in a high cost and low revenue scenario. RDF-related options have low, positive costs that become negative in a high revenue and low cost scenario. Only MBT exceeds 1 USD/tons of CO_2 eq. in all scenarios.

A prioritization of mitigation options according to our C&I leads to RDF for co-processing in cement plants, composting, and biomethanation as the preferred options.

We now differentiate two routes to define NAMA options – one built around a concrete mitigation option and one built around a specific policy instrument.

The first route is based on the choice of a preferred mitigation option. This mitigation option is a particularly promising technology with regards to the fulfilment of the C&I both with regards to greenhouse gas mitigation and economic, environmental, social and technological co-benefits. In order to remove barriers to the implementation of the technology, a set of regulatory and fiscal policy instruments as well as capacity building activities is identified that is best suited to overcome the barriers and lead to a rapid penetration of the mitigation option. So the NAMA would be "tailor-made" for the specific mitigation option. The advantage of such an approach is that it may face less political barriers than a sweeping reform of policy instruments. A disadvantage is that the mitigation potential harnessed by the NAMA is constrained to the technical potential of the underlying mitigation option. A mitigation-option based NAMA can be implemented relatively quickly provided strong alliances of stakeholders benefitting from technology implementation can be formed on the local and state level.

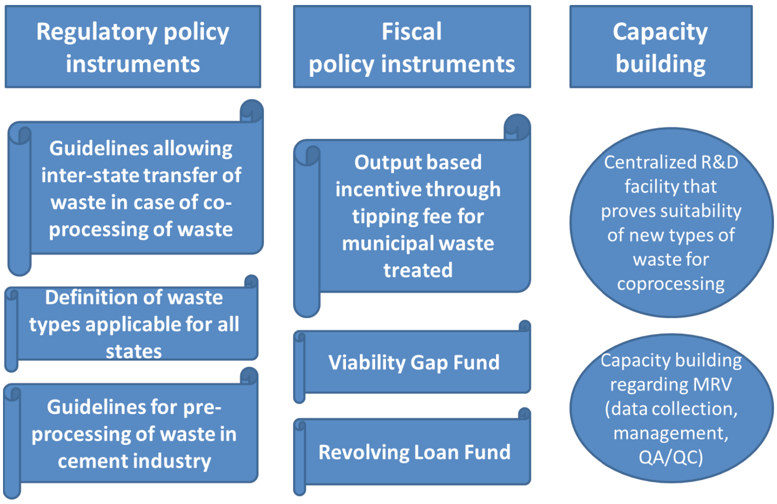
The second route is based on the observation that many barriers to implementation of mitigation options are not specific to any technology. For example, a major barrier is the absence of economic incentives for low-carbon waste management technologies. Therefore, the introduction of policy instruments that provide revenues for waste treatment is likely to mobilize many mitigation options in parallel. The key advantange of this approach is that it can really transform the SWM sector.

Its major drawback is that the political will to provide the resources underpinning the policy instrument may be difficult to mobilize. Governments on all levels need to fully engage and a "window of opportunity" may have to open before sufficient support materializes.

The first route can directly be applied to the three mitigation options prioritized through the assessment of C&I. For the second route, we see two promising options. The first option would be based on economic incentives and is thus called "Waste treatment incentives with technology-differentiated results-based payments", while the second would address the barrier of lacking enforcement of key waste policies. It would focus on enforcement of mandatory segregation of waste.

Assessing these five NAMA options regarding their feasibility, we recommend to focus on two options. However, we want to stress that before the SWM NAMA is designed in detail, the assessment should be deepened. ***The preferred short-term NAMA option is RDF for co-processing in cement plants***. Its design is shown in Figure 41.

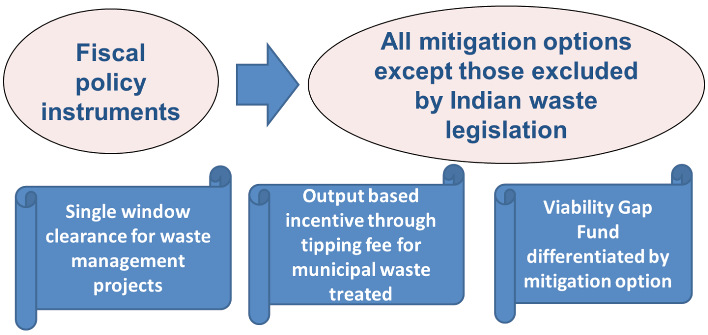
Figure 41: NAMA option for RDF from MSW for co-processing in cement industry



Next to the most promising technology-driven, short-term NAMA option described above, the other two most relevant NAMA mitigation options identified are ***Composting and vermicomposting*** and ***Biomethanation***. As above, these mitigation options would be accompanied by a set of policy instruments and capacity building measures (see Section 9.1).

The second, more long-term oriented option is the introduction of fiscal policy instruments providing waste treatment incentives with technology-differentiated results-based payments (see Figure 42).

Figure 42: NAMA option for waste treatment incentives with technology-differentiated results-based payments



Stakeholder consultations have shown that significantly increased waste treatment fees could improve the viability of low-GHG SWM treatment options, as well as the improvement of markets for products of waste treatment such as compost. A central government level fee for each t SWM properly treated would be preferable; a second best solution would be state level fees. In order to provide sufficient trust in the long-term availability of the incentive, a ring-fenced budget for at least five years should be provided by GoI, ideally under the framework of Swachh Bharat.

High cost waste treatment projects with high sustainable development cobenefits should be eligible for government subsidies to close the viability gap. GoI should undertake to access international climate finance institutions and channel through the revenues to operators of waste treatment in form of a results-based incentive which remunerates each t CO_2 eq. mitigated.

Regardless of the NAMA options chosen, an Indian SWM NAMA should have a time horizon of at least five years to overcome critical barriers. The overall duration of the NAMA should be until 2030 to achieve a transformation of the sector.

Administration of the MRV system needs to be done centrally, e.g. through a NAMA cell at MoEFCC. Given the glaring absence of data on projects a central data is required. Given the experience of waste-related CDM projects with roughly estimated, overly optimistic data, the NAMA cell should revalidate data as soon as sufficient empirical evidence accumulates in order to prevent failure of mitigation options.

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Appendices

Appendices

Appendix 1: Waste generation, collection and treatment on the state level

WASTE GENERATION

State	Quantity generated tons per day (tPD)	% Generated
Maharashtra	26,820	19%
Uttar Pradesh	19,180	13%
Tamil Nadu	14,532	10%
Andhra Pradesh	11,500	8%
Karnataka	9,500	7%
Gujarat	9,227	6%
West Bengal	8,674	6%
Delhi	7,500	5%
Madhya Pradesh	5,079	4%
Rajasthan	5,037	3%

WASTE COLLECTION

State	Collected (tPD)	% Collected
Maharashtra	14,900	16%
Tamil Nadu	14,532	16%
Andhra Pradesh	10,656	11%
Gujarat	9,227	10%
West Bengal	7,196	8%
Karnataka	5,700	6%
Delhi	4,500	5%
Madhya Pradesh	4,298	5%
Punjab	3,853	4%
Haryana	3,440	4%

WASTE TREATMENT

State	Treated (tPD)	% Treated
Andhra Pradesh	9,418	35%
Maharashtra	4,700	17%
Delhi	2,500	9%
Karnataka	2,000	7%
Tamil Nadu	1,607	6%
West Bengal	1,415	5%
Gujarat	1,354	5%
Madhya Pradesh	802	3%
Haryana	570	2%
Rajasthan	490	2%

Ranking of States as per their waste - Generation, Collection and Treatment in year 2013-14 (CPCB, 2013-14)*

**Some of the states/ union territories like Uttar Pradesh, Bihar, Uttarakhand, Mizoram, Puducherry, Manipur, Daman Diu & Dadra and Lakshadweep have not reported collected and treated quantity of waste. Some states/ union territories like Tamil Nadu, Punjab, Gujarat, Puducherry, Tripura, Mizoram, Goa, Arunachal Pradesh, Sikkim have reported 100% collection of waste. Goa has reported 100% treatment of waste in 2013-14*

Appendix 2: List of 118 sample cities used for estimation of decadal population for identified city groups

No	City	Reference for decadal population data
1	Hinganghat (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
2	Kasganj (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
3	Dhamtari UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
4	Baraut (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
5	Udgir (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
6	Ballia (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
7	Wardha (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
8	Shamli (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
9	Shikohabad (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
10	Sultanpur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
11	Kanpur (CB)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
12	Mughalsarai (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
13	Ghazipur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
14	Azamgarh (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
15	Nandurbar (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
16	Khurja (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
17	Osmanabad (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
18	Achalpur (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory

No	City	Reference for decadal population data
19	Chandausi (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
20	Gonda (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
21	Ambikapur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
22	Basti (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
23	Chalakudy UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
24	Bijnor UA	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
25	Yavatmal (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
26	Mainpuri (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
27	Barshi (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
28	Etah (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
29	Satara (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
30	Hardoi (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
31	Changanassery UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
32	Deoria (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
33	Modinagar (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
34	Pilibhit (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
35	Palakkad (M)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
36	Gondiya (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
37	Lalitpur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory

No	City	Reference for decadal population data
38	Kamptee UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
39	Raigarh (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
40	Hathras (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
41	Bid (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
42	Lakhimpur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
43	Banda (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
44	Budaun (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
45	Rajnandgaon (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
46	Faizabad (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
47	Jaunpur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
48	Simla (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
49	Alappuzha (M)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
50	Sitapur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
51	Unnao (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
52	Bahraich (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
53	Orai (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
54	Bhusawal (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
55	Rae Bareli (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
56	Kasaragod UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
57	Fatehpur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory

No	City	Reference for decadal population data
58	Amroha (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
59	Sambhal (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
60	Bulandshahr (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
61	Mirzapur-cum-Vindhyachal (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
62	Ottappalam UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
63	Etawah (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
64	Hapur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
65	Durg (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
66	Farrukhabad-cum-Fatehgarh (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
67	Maunath Bhanjan (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
68	Jalna (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
69	Ichalkaranji (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
70	Parbhani (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
71	Thrissur (M.Corp)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
72	Chandrapur (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
73	Rampur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
74	Shahjahanpur (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
75	Bilaspur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
76	Kollam (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory

No	City	Reference for decadal population data
77	Mathura (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
78	Ahmadnagar (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
79	Kottayam UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
80	Korba (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
81	Dhule (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
82	Latur (M Cl)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
83	Muzaffarnagar (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
84	Kayamkulam UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
85	Akola (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
86	Kozhikode (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
87	Cherthala UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
88	Jalgaon (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
89	Sangli Miraj Kupwad (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
90	Ulhasnagar (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
91	Jhansi (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
92	Nanded Waghala (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
93	Kochi (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory

No	City	Reference for decadal population data
94	Firozabad (NPP)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
95	Amravati (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
96	Gorakhpur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
97	Saharanpur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
98	Bhiwandi (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
99	Thiruvananthapuram (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
100	Mira-Bhayander (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
101	Aligarh (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
102	Moradabad (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
103	Bareilly (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
104	Solapur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
105	Raipur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
106	Allahabad (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
107	Aurangabad (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
108	Kalyan-Dombivali (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
109	Meerut (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
110	Nashik (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
111	Agra (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
112	Kannur UA	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory

No	City	Reference for decadal population data
113	Pimpri-Chinchwad (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
114	Thane (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
115	Ghaziabad UA	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
116	Nagpur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001: Primary census abstract 2001, Reference for 1991, 1981, 1971, 1961: Data from town directory
117	Kanpur (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory
118	Lucknow (M Corp.)	Reference for 2011: Census 2011, Reference for 2001, 1991, 1981, 1971, 1961: Data from town directory

1.1 Appendix 3: City reports used for estimation of waste generation rate

Name of City	Reference
Agartala (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Agra (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Ahmedabad (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Aizawl (NT)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Allahabad (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Amritsar (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Bangalore	H N Chanakya1, T V Ramachandra and Shwetmala, Towards a sustainable waste management system for Bangalore, http://saahas.org/wp-content-saahas/uploads/2015/02/SWMindia11.pdf
Bhavnagar (M.Corp)	Blogspot data

Name of City	Reference
Bhilai (M.Corp)	DPR-ADEPT-BDMC-2010-V1 "Detailed Project Report for Fully Integrated Municipal Solid waste Management Project For Bhilai & Durg Municipal Corporation", Submitted to: State Urban Development Agency, on June 2010
Bhopal (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Bhubaneswar (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Chandigarh (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Chennai (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Daman (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Delhi (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Dehradun (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Deoli (M.Corp)	DPR-ADEPT-RUDA -TMC-2014-V1, "Detailed Project Report for an Integrated Municipal Solid Waste Management for Package-16 cities", June 2015
Dhanbad (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
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Faridabad (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Gandhinagar (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Gangapur City (M.Corp)	"Detailed Project Report for an Integrated Municipal Solid Waste Management for Package-15 cities (Sawaimadhopur and Gangapur city)", June 2014

Name of City	Reference
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Guwahati (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Hubli-Dharwad (M.Corp)	DPR-ADEPT-HDMC-2011 "Detailed Project Report for an Integrated Municipal Solid Waste Management at Hubli-Dharwad Municipal Corporation" August 2011
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Jammu (M.Corp)	http://www.cpcb.nic.in/divisionsofheadoffice/pcp/MSW_Report.pdf
Kanpur (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Kochi (M.Corp)	"ASEM Advisory Services in Environmental Management Indo-German Technical Cooperation" May 2009
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Kozhikode (M.Corp)	http://www.sanitation.kerala.gov.in/pdf/staeof_solidwaste.pdf

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Lucknow (M.Corp)	Solid Waste Management and Characteristics in Lucknow, Uttar Pradesh, India, International Journal of Scientific & Engineering Research, Volume 4, Issue 11, November-2013, http://www.ijser.org/researchpaper%5CSolid-Waste-Management-and-Characteristics-in-Lucknow-Uttar-Pradesh-India.pdf
Ludhiana (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Meerut (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Mumbai (Greater M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Newai (M.Corp)	DPR-ADEPT-RUDA -TMC-2014-V1, "Detailed Project Report for an Integrated Municipal Solid Waste Management for Package-16 cities", June 2015
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Patna (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Pondicherry	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Pondicherry + Oulgaret (UD)	Paradigm DPR
Port Blair (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Pune	Nitin Mundhe et al, Assessment of Municipal Solid Waste Management of Pune City using Geospatial Tools, International Journal of Computer Applications (0975 – 8887), Volume 100– No.10, August 2014
Puri	Website:http://www.ceeindia.org/cee/project_pages/SWM_Puri.html
Raipur (M.Corp)	"ASEM Advisory Services in Environmental Management Indo-German Technical Cooperation" May 2009
Rajkot (M.Corp)	Rajkot Municipal Corporation, June 2006
Sawaimadhopur (M.Corp)	"Detailed Project Report for an Integrated Municipal Solid Waste Management for Package-15 cities (Sawaimadhopur and Gangapur city)", June 2014
Shillong (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf

Name of City	Reference
Silvassa (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Simla (M.Corp)	"ASEM Advisory Services in Environmental Management Indo-German Technical Cooperation" May 2009
Simla	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Srinagar (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Surat (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Tiruvananthapuram	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
Todaraisingh (M.Corp)	DPR-ADEPT-RUDA -TMC-2014-V1, "Detailed Project Report for an Integrated Municipal Solid Waste Management for Package-16 cities", June 2015
Varanasi (M.Corp)	"ASEM Advisory Services in Environmental Management Indo-German Technical Cooperation" May 2009
Vijaywada (M.Corp)	Technical EIA guidance manual for common MSWM facilities prepared for MoEF, GOI (IL&FS Environment Ecosmart Lmt. Hyderabad Sep. 2010) (2004-2005) http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf
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Appendix 4: Year wise GHG emissions inventory of urban MSW ($kt\ CO_2$ eq)

Year	20,000 to 100,000	100,000 to 500,000	500,000 to 1 million	1-5 million	Above 5 million	Emissions from biological treatment	Total sector emissions
1961	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1962	92.09	64.02	19.11	51.47	93.60	0.00	320.29
1963	162.00	115.08	34.55	92.06	167.01	0.00	570.70
1964	216.97	157.16	47.48	125.32	226.70	0.00	773.63
1965	261.90	193.00	58.66	153.66	277.08	0.00	944.30
1966	300.08	224.49	68.65	178.74	321.15	0.00	1093.11
1967	333.78	252.95	77.82	201.66	360.96	0.00	1227.15
1968	364.51	279.29	86.43	223.19	397.93	0.00	1351.34
1969	393.32	304.17	94.68	243.87	433.04	0.00	1469.08
1970	420.94	328.06	102.69	264.07	466.99	0.00	1582.74
1971	447.87	351.29	110.56	284.04	500.25	0.00	1694.02
1972	474.45	374.13	118.37	303.97	533.19	0.00	1804.12
1973	503.03	398.93	126.61	325.67	568.40	0.00	1922.64
1974	533.22	425.34	135.23	348.82	605.51	10.57	2058.69
1975	564.80	453.14	144.18	373.20	635.34	31.72	2202.37
1976	597.59	482.18	153.45	398.68	651.21	52.87	2335.97
1977	631.51	512.35	163.02	425.16	657.12	74.02	2463.19
1978	666.50	543.61	172.88	452.60	655.89	95.17	2586.65
1979	702.53	575.91	183.03	480.95	649.50	116.31	2708.23
1980	739.57	609.22	193.46	510.20	639.37	137.46	2829.29
1981	777.63	643.54	204.19	540.34	626.53	158.61	2950.85
1982	816.71	678.87	215.21	571.37	611.75	179.76	3073.67
1983	857.36	717.83	229.67	612.91	597.56	200.91	3216.23
1984	899.47	759.83	246.85	662.57	583.92	222.06	3374.71
1985	942.95	804.48	266.29	718.71	570.88	243.21	3546.52
1986	987.76	851.50	287.63	780.22	558.47	264.36	3729.94
1987	1033.85	900.71	310.65	846.33	546.78	285.51	3923.83
1988	1081.24	951.97	335.16	916.52	535.89	306.66	4127.43
1989	1129.91	1005.21	361.04	990.41	525.88	327.81	4340.26
1990	1179.88	1060.34	388.21	1067.77	516.85	348.96	4562.03
1991	1231.16	1117.36	416.62	1148.43	508.90	370.11	4792.57
1992	1283.77	1176.22	446.20	1232.28	502.10	391.26	5031.83
1993	1336.14	1240.17	478.99	1335.46	526.16	412.41	5329.32
1994	1388.70	1308.48	514.50	1453.88	574.02	433.56	5673.15
1995	1441.78	1380.65	552.41	1584.75	640.85	454.71	6055.15
1996	1495.59	1456.34	592.47	1726.16	723.33	475.86	6469.75
1997	1550.28	1535.31	634.53	1876.79	819.17	497.01	6913.10
1998	1605.98	1617.39	678.48	2035.77	926.81	518.16	7382.57
1999	1662.77	1702.47	724.24	2202.46	1045.15	539.31	7876.39

Year	20,000 to 100,000	100,000 to 500,000	500,000 to 1 million	1-5 million	Above 5 million	Emissions from biological treatment	Total sector emissions
2000	1720.73	1790.49	771.75	2376.47	1173.44	560.46	8393.33
2001	1779.91	1881.41	820.98	2557.51	1311.19	581.61	8932.60
2002	1840.38	1975.20	871.91	2745.41	1458.04	602.76	9493.69
2003	1903.81	2069.36	925.48	2957.22	1611.82	623.91	10091.60
2004	1969.81	2164.45	981.49	3188.60	1772.87	645.06	10722.28
2005	2038.14	2260.89	1039.78	3436.60	1941.44	666.21	11383.05
2006	2108.62	2358.96	1100.25	3699.22	2117.74	687.35	12072.15
2007	2181.16	2458.91	1162.86	3975.10	2301.94	708.50	12788.47
2008	2255.70	2560.90	1227.56	4263.32	2494.19	729.65	13531.32
2009	2332.20	2665.08	1294.34	4563.28	2694.65	750.80	14300.34
2010	2410.66	2771.56	1363.18	4874.59	2903.44	771.95	15095.39
2011	2491.09	2880.45	1434.10	5197.00	3120.72	793.10	15916.47
2012	2573.50	2991.84	1507.10	5530.39	3346.63	814.25	16763.72
2013	2661.67	3098.86	1574.66	5852.25	3660.87	835.40	17683.70
2014	2754.64	3203.20	1638.54	6168.17	4044.38	856.55	18665.49
2015	2851.77	3306.09	1699.98	6482.06	4484.14	856.55	19680.60
2016	2952.64	3408.43	1759.85	6796.64	4989.07	856.55	20763.18
2017	3056.96	3510.88	1818.82	7113.83	5548.15	856.55	21905.19
2018	3164.57	3613.94	1877.36	7435.03	6153.75	856.55	23101.19
2019	3275.35	3717.99	1935.84	7761.27	6800.59	856.55	24347.59
2020	3389.25	3823.34	1994.53	8093.33	7484.99	856.55	25641.99
2021	3506.24	3930.25	2053.67	8431.81	8204.38	856.55	26982.91
2022	3626.32	4038.93	2113.43	8777.21	8956.99	856.55	28369.44
2023	3749.50	4149.56	2173.95	9129.94	9741.61	856.55	29801.12
2024	3875.81	4262.30	2235.38	9490.33	10557.42	856.55	31277.80
2025	4005.29	4377.30	2297.81	9858.71	11403.91	856.55	32799.55
2026	4137.96	4494.68	2361.34	10235.35	12280.76	856.55	34366.64
2027	4273.89	4614.57	2426.06	10620.52	13187.84	856.55	35979.44
2028	4413.12	4737.09	2492.06	11014.47	14125.14	856.55	37638.43
2029	4555.70	4862.34	2559.40	11417.45	15092.75	856.55	39344.20
2030	4701.70	4990.44	2628.16	11829.68	16090.84	856.55	41097.38

Appendix 5: Sources referred to for preparation of the proposed Criteria & Indicator Framework

Sn	Description	Source of Reference
1	Screening Tool - Screening Potential Transport NAMAs – A Decision Support Tool - GIZ	http://transport-namas.org/wp-content/uploads/2014/05/Toolbox_Screening-Tool_20120802.pdf
2	Mapping of Criteria set by DNAs to Assess Sustainable Development Benefits of CDM Projects - TERI	http://www.cdmpolicydialogue.org/research/1030_mapping.pdf
3	NAMA Facility	http://nama-facility.org/fileadmin/user_upload/pdf/NAMA_Facility_General_Information_Document_April2014.pdf
4	The Gold Standard	http://www.goldstandard.org/wp-content/uploads/2011/11/DeveloperManual_GS-CER.pdf
5	UNFCCC SD Tool	https://cdm.unfccc.int/Reference/tools/index.html
6	TERI NAMA tool	http://unfccc.int/files/focus/mitigation/application/pdf/presentation_teri_220414.pdf
7	CCAP	http://mitigationpartnership.net/sites/default/files/2012_ccap_cerqueira_mrv_of_namas_guidance_for_selecting_sustainable_development_indicators.pdf
8	Planning Commission report on WTE - 2014 – Vol. I	http://planningcommission.nic.in/reports/genrep/rep_wte1205.pdf

Appendix 6: List of Sustainable Development Criteria/Indicators prescribed by NCDMA (revised)

Category	Sub-Category	Criteria/Indicators
Social well being	Promotion of Food and Livelihood Support Activities	Poverty alleviation
		Livelihood support activities
		Providing employment
	Development of Basic Infrastructure	Drinking water
		Irrigation
		Communication
		Road connectivity
		Basic health
	Support for Education and Training	Primary education
		Training
	Accessibility of Electricity/Clean Energy	Access to electricity
		Availability of clean energy in unelectrified village(s)
Economic well being	Investment in line with the Government Policy	Is it supporting development goal of the government?
		Is it supporting activities promoted by the state & local government?
		Investment considering basic requirement of local communities
	Additional employment local communities	Business
		Supply, Trade and Marketing
		Providing support services
		Others activities
	Ensured resettlement and rehabilitation for affected villager(s) (if applicable)	Land acquirement norms for affected villager(s)
		How were the displaced people resettled and rehabilitated?
		Did the affected villager(s) receive proper compensation for the land?
Environmental Well Being	Save Guarding forest(s) and Natural Resource(s)	Forest(s)
		Diversity
		Wildlife
		Water-bodies
		Cultivable/Agricultural land
	Protecting Environment	Air pollution
		Water pollution
		Noise pollution
		Contamination of soil
		Bad odour/dust problem(s)
		Persistent Organic Pollutants
		Ozone depleting substances
	Supporting Environment for Health and Welfare	Human health
		Agriculture
		Animal husbandry
		Fisheries
		Other livelihood issue(s) affected by this project

Category	Sub-Category	Criteria/Indicators
Technology Well Being	Promotion of Technology Transfer	Is it supporting technology transfer?
		Is it a simple technology outsourcing for the project activity?
		Is there any provision for technology transfer along with outsourcing?
	In-house Technology Development	Developing technology in-house
		Supporting institutional capacity for in-house development
		Establishing manufacturing hub in the country with R & D facility
	Diffusion of Technology in the Country	Is the technology used free from risk, safety and hazards?
		Is it supporting the basic requirement(s) with affordable cost?

Appendix 7: List of Sustainable Development Criteria/Indicators as per GIZ's International template for NAMA formulation

Category	Sub-Category	Criteria/Indicators
Social sustainability	Labor conditions and/ or human rights	Improvement in the working and/or living conditions of skilled/ unskilled labor in the region/ sector/ country
	Promotion of education	Improved accessibility of educational resources or donating resources for local education
	Health and safety	Improvements to health, safety and welfare of local people through a reduction in exposure to factors impacting health and safety
	Poverty Alleviation	Emphasis on the country's/ region's/ local area's poverty alleviation policies/ programs/ activities
	Engagement of local population	Community involvement in decision-making; training of unskilled workers; reduction of urban migration
	Empowerment	Enhancement in the position of women & children in society
Economic sustainability	Direct/ Indirect financial benefit for the local and/or regional economy	Economic improvements for the population through domestic or community savings
		Economic improvement through income generation for local communities
		Poverty reduction
		Support for entrepreneurial activity in local economy
		Financial benefits of the NAMA for national economy
		Reinvestment of the NAMA proceeds, if any, into the community
	Local/ regional jobs generated directly/ indirectly	Economic improvements through direct job creation in the NAMA implementation/ conceptualization phase
		Economic improvements through direct job creation in the NAMA operational phases
		Economic improvements through indirect job creation
	Investment in local/ regional infrastructure	Creation of infrastructure (e.g. roads and bridges) and improved service availability (e.g. health centres and water availability)
Environmental sustainability	Reduction in noise, odors, dust or pollutants	Reduction in gaseous emissions (including ODS)
		Reduction in effluents
		Reduction in solid waste
		Reduction in noise
		Reduction in odor
		Enhancement of indoor air quality
	Improvement or protection of natural resources	Improvement / protection of soil fertility
		Improvement / protection of biodiversity
		Improvement of water quality
	Available utilities	Supply more energy
		Making use of less energy
	Promotion of renewable energy	Converting or adding to the country's/ region's/ local area's energy capacity that is generated from renewable sources
Technological sustainability	Development/ diffusion of technology	Development/ diffusion of new technology
		Diffusion of imported new technology
		Increase in financial viability of efficient technologies

Appendix 8: GCF's Criteria and Indicators for screening of projects

No.	Criteria Category	Definition	Example of criterion	Example of indicators from other funds
I.	Impact/result potential	Potential to contribute to the achievement of a fund's objectives and result areas	Expected reductions in greenhouse gas emissions	Net carbon intensity of the new gas-fired power plant, or new units within an existing plant for coal-tired power plants (Clean Technology Fund)
2.	Trainformational potential	Degree to which a fund can achieve impact beyond a one-off project or programme investment through replicability and scalability	Trainformational potential	Measured by the ratio of the trajectory of reduced emissions that would result if the financed project or programme were to be replicated throughout the targeted area, region, and/or sector over emissions reduction from project or programme alone (High ratio would have more transformational potential than smaller ratio) (Clean Technology Fund)
3.	Needs of beneficiary	Degree to which a beneficiary needs the finance more than others, or is relatively lest capable than others to fulfill this need through other funding sources	Relative vulnerability of a population to climate change impacts (e.g. populations living in low-lying Rood-prone areas)	Country's ranking in the Human Development Index (Pilot Programme for Climate Resilience)
4.	Institutional capacity	Beneficiary's capacity to implement a funded project or programme (policies, regulations and institutions)	Supportive country policy and institutional frame%mark (hot:: ambition and outcome)	Scoring of oauntry policies and institution additional weight given to environment-related policies and institutions (Global Environment Facility)
5	Economic Efficiency	Benefit-cost balance of activity: impact per US dollar delivered by a Fund	Avoided deforestation or forest degradation	Number of hectares affected per US dollar spent (Amazon Fund)
6.	Financial viability (for revenue-generating activities)	Activity is financially sound	Funded activity covers its costs net of grants over lifetime of project	Project financial return (International Development Agency)

Source: (GCF Board, 2014)

Indicator type	Mitigation
Impact/result potential	a. tCOreq reduced through improved governance and planning systems for sustainable tides: b. Reduced emissions from buildings and appliances HCOr.eq/mr); c. Increased access to transportation with low.cerbon transportation options (tC0a-passenger km); d. Reduced emission intensity of Industrial production (ICOr.eq/year): e. Households with access to low.cerbon modern technologies (Number of households served by off-grid or cited), f. Identifiable on-grid renewable technoiogim): g. Deployment of low-carbon power generation technologies (tCtIlt/kWh): h. Reduced emissions from sustainable land use management (CO:wq/year); and i. pH Support to development of negative emission technologies (Number of carbon rapture and storage projects, KOs sequestered).
paradigm shift potential	a. Carbon Intensity of nationally determined sectors (tCO:/gross domestic product): b. Facilitating the design of sustainable cities (ICOileanita).

Appendix 9: The Gold Standard Principles and Criteria

Principle 1 **The project shall do no harm, complying with the UNDP Millennium Development Goals (MDG) Carbon Safeguard Principles.**	1.1 The project shall assess the risk of potential harmful impacts against a series of safeguarding principles on human rights, labor standards, environmental protection and anti-corruption. These safeguarding principles are derived from the UNDP MDG Carbon Facility1 , UN Millennium Development Goals2 and international conventions. Projects shall identify potential negative impacts based on these safeguarding principles and avoid, mitigate, or repair them.
Principle 2 The project shall enhance sustainable development.	2.1 The project shall demonstrate a net positive contribution to sustainable development through completion of a detailed impact assessment using Gold Standard tools. 2.2 The project shall be assessed within a sustainable development matrix against a series of sustainable development indicators that are pre-defined for different project types.
Principle 3 The project shall involve all relevant stakeholders.	3.1 An extensive stakeholder consultation process is required during which the community defines the most important indicators of social, economic and environmental success. This shall enable stakeholders to influence the project design. 3.2 All Gold Standard NGO Supporters can support the local stakeholder consultation process and are invited to provide input for every project at defined points in the certification process. 3.3 A grievance mechanism enables stakeholders to provide continuous feedback on the project.
Principle 4 Greenhouse gas emission reductions and carbon sequestration shall be real.	4.1 The emission reductions and carbon sequestration delivered by a project shall be thoroughly and accurately measured as well as reviewed by an approved independent third party AND The Gold Standard Secretariat. 4.2 The project shall demonstrate that emission reductions and carbon sequestration are above business as usual.
Principle 5 The project shall be compliant with all relevant laws and Gold Standard Principles.	5.1 The project shall follow the certification steps as outlined in the specific requirements for each scope and project type to ensure compliance with Gold Standard Principles. 5.2 The project developer shall sign a Gold Standard declaration confirming that the project is compliant with local laws and relevant international laws. 5.3 The project shall demonstrate that property ownership and rights have been determined and clearly documented.
Principle 6 The project shall be transparent.	6.1 The project's information shall be well documented to enable reproducibility and tracing of certified information. Project documents shall be made public on The Gold Standard Registry.
Principle 7 The project's compliance and progress shall be monitored, reported and independently verified throughout the entire crediting period.	7.1 The project shall have a Monitoring Plan, based on the outcome of the do-no-harm assessment and detailed sustainable development impact assessment, to ensure that the project indeed contributes to sustainable development and does no harm. The parameters in the Monitoring Plan shall be regularly monitored, clearly reported on and independently verified. 7.2 Independent, accredited certification bodies shall verify that the project meets all rules and that all claims and calculations are accurate. 7.3 The Gold Standard Secretariat shall review all documentation and may require corrections or enhancements where needed to ensure that a project meets Gold Standard requirements. These corrections or enhancements may take place after the third party audit if that is deemed to be incomplete or incorrect.

Appendix 10: List of MSW projects in CDM pipeline not yet commissioned

UN Ref	Title	Location state
2378	Integrated Municipal Waste Processing Complex at Ghazipur, Delhi	Delhi
2505	Establishment of Compost Production Unit of 100 TPD at Lalganj	Uttar Pradesh
2944	Gorai Landfill closure and Gas Capture Project, Mumbai, India	Maharashtra
3630	Expansion of Nature and Waste Bhalaswa Composting Plant at Delhi	Delhi
6841	Avoidance of methane emissions by installing a Composting Facility at Madurai, India	Tamil Nadu
7790	Power generation through MSW at Karimnagar, Andhra Pradesh	Andhra Pradesh
8050	Integrated Solid Waste Management Project at Allahabad, Uttar Pradesh	Uttar Pradesh
9272	Integrated Solid Waste Management Project at Mathura, Uttar Pradesh	Uttar Pradesh
CDM terminated	Municipal Solid Waste processing (MSW) in the city of Rajkot, India" at Hanjer Biotech Energies (P) Ltd in Nakrawadi Village, Rajkot, Gujarat by M/s Hanjer Biotech Energies (P) Ltd	Gujarat
CDM terminated	KCDC Bangalore Composting Project	Karnataka
CDM terminated	SBES waste to energy project	Maharashtra
CDM terminated	SGRRL Municipal Solid Waste Project	Karnataka
CDM terminated	Landfill Gas capture and Electricity generation Project by Terra Firma Biotechnologies Ltd, Karnataka, India	Karnataka
CDM terminated	Biomethanation of Municipal Solid Waste (MSW) by Terra Firma Biotechnologies Ltd., Karnataka, India	Karnataka
CDM terminated	Composting of Municipal solid waste by Terra Firma Biotechnologies Ltd. Karnataka, India	Karnataka
CDM terminated	Municipal Solid Waste treatment at Dhapa Landfill	West Bengal
CDM terminated	Integrated Solid Waste Management, Processing and Utilisation System of the Township Project	Maharashtra
CDM terminated	Municipal Solid Waste Management Project at Navi Mumbai Municipal Corporation.	Maharashtra
CDM terminated	Composting Project at Coimbatore in Tamil Nadu, India	Tamil Nadu
CDM terminated	The Timarpur Waste Management Company Pvt Ltd (TWMCPL) 6 MW waste to energy project at Timarpur, Delhi.	Haryana
CDM terminated	13 MW Municipal Solid Waste to Energy Project near Rajahmundry, Andhra Pradesh, India	Andhra Pradesh
CDM terminated	Municipal Solid Waste Processing project – Project 3	Maharashtra
CDM terminated	Municipal Solid Waste Processing project -Project 4	Gujarat
CDM terminated	Municipal Solid Waste Processing project -Project1	Maharashtra & Gujarat
CDM terminated	Municipal Solid Waste (MSW) processing project - Project 5	Tamil Nadu

UN Ref	Title	Location state
CDM terminated	Municipal Solid Waste Processing project- Project 2	West Bengal
CDM terminated	Integrated treatment facility for Municipal Solid Waste at Bangalore, Karnataka, India	Karnataka
CDM terminated	Shriram 6 MW Municipal Solid Waste Management cum Energy Generation Project, Vijayawada, India	Andhra Pradesh
CDM terminated	Power generation through MSW at Karimnagar, Andhra Pradesh, India	Andhra Pradesh
CDM terminated	Integrated treatment facility for Municipal Solid Waste at Bangalore, Karnataka, India.	Karnataka
CDM terminated	SBES waste to energy project	Maharashtra
CDM terminated	Municipal Solid Waste processing (MSW) in the city of Rajkot	Gujarat
CDM terminated	6,6 MW MSW to electricity generation project in Hyderabad	Andhra Pradesh
CDM terminated	Avoidance of methane emissions by installing a Composting Facility at Madurai, India.	Tamil Nadu
CDM terminated	Integrated Solid Waste Management Project at Mathura, Uttar Pradesh.	Uttar Pradesh
9456	Landfill Closure and Gas capture CDM project by GAIL at Ghazipur, India	Delhi
Under validation	RDF Power Projects Ltd. – Integrated Solid Waste Management Project	Andhra Pradesh
Under validation	12.6 MW MSW based power generation project at Nalgonda by HSPPL	Andhra Pradesh
Under validation	Avoidance of methane from biomass decay by up gradation and capacity enhancement of the existing Municipal Solid Waste (MSW) composting plant in Shillong, Meghalaya	Meghalaya
Under validation	"Integrated Municipal Solid Waste processing complex at Kanpur in Uttar Pradesh, India"	Uttar Pradesh
Under validation	Integrated Municipal Solid Waste processing complex	Uttar Pradesh
Under validation	Methane emission avoidance through treatment of municipal solid wastes in Lucknow, Uttar Pradesh, India	Uttar Pradesh
Under validation	Municipal Solid Waste management project at Meerut, India	Uttar Pradesh
Under validation	Municipal Solid Waste management project at Moradabad, India	Uttar Pradesh
Under validation	Integrated Municipal Solid Waste processing complex at Indore, Madhya Pradesh, India	Madhya Pradesh
Under validation	Municipal Solid Waste management project at Varanasi,	Uttar Pradesh
Under validation	Municipal Solid Waste management project at Aligarh, India	Uttar Pradesh
Under validation	Integrated Solid Waste Management project for Dehradun, Uttrakhand, India	Uttarakhand

Appendix 11: NAMAs in waste sector submitted to UNFCCC

No.	NAMA title	Country	Stage	Sector	Source of Waste	Key Activities
1	National Program for Catalyzing Industrial and Commercial Organic Waste Management in Chile	Chile	Seeking Support for Implementation	Waste management	1) Industrial organic waste produced by agro-industry *(wine, fruits, crops), fisheries (salmon), livestock (poultry, pigs)* 2) commercial organic waste generated *from pruning activities and the operation of local food markets, hotels and restaurants*	1) Develop national norms to regulate organic waste management; 2) Install organic waste treatment plants; 3) Co-finance feasibility studies; 4) Develop a system for the monitoring, reporting and verification of the emissions reductions resulting from plant installations that result from this NAMA.
2	Low Carbon Climate Resilient Development Strategy	Dominica	Seeking Support for Implementation	Agriculture Forestry Waste management Energy supply Residential and Commercial buildings Industry Transport and its Infrastructure	not available	Integration of green principles into national economic management and planning for achieving higher levels of sustained economic growth.
3	NAMA in Cement/Co-Processing and Waste Sector	Dominican Republic	Seeking Support for Implementation	Waste management Industry	**1) Municipal waste** 2) Industrial waste	**1) Models for an inclusive supply chain of alternative fuel and raw material (AFR) from municipal and industrial wastes to co-processing in the cement production.** 2) Inter-institutional platform for dialogue between relevant stakeholders of the public and private sectors for setting up a legal framework and administrative procedure for co-processing waste materials that follow international standards

No.	NAMA title	Country	Stage	Sector	Source of Waste	Key Activities
4	Tourism and Waste in the Dominican Republic	Dominican Republic	Seeking Support for Implementation	Waste management, Energy supply	1) Tree and shrub refuse/ clippings from hotel properties 2) Separated organic waste or other regional biomass sources	Achieve wide-spread adoption of alternative energy technologies and address waste management in the tourism sector in Dominican Republic (with focus on Bavaro-Punta Cana region –the largest tourist district in the country)
5	Rehabitation Of Al-Akaider L andfill	Jordan	Seeking Support for Preparation	Waste management	not available	Technical Solutions for the project in terms of financial environmental, social and institutional criteria
6	National appropriate mitigation action (NAMA) for national domestic waste management	Jordan	Seeking Support for Preparation	Waste management	1) domestic waste (solid waste and wastewater)	Develop national strategy for domestic waste (solid waste and wastewater) management to reduce the greenhouse gases (GHGs) emissions by at least 1 Gg CO2 eq annually since according to Jordan's Second National Communication
7	Nationally Appropriate Mitigation Actions for Low-carbon Urban Development in Kazakhstan	Kazakhstan	Seeking Support for Preparation	Waste management Energy supply Residential Commercial buildings Transport and its Infrastructure	not available	The Project supports the identification, design, and implementation of NAMAs in the urban sector. Improve the capacity of municipalities to carry out integrated municipal planning, make targets and prioritize urban mitigation actions.
8	Urban NAMA	Mexico	Seeking Support for Preparation	Waste management, Residential and Commercial buildings Transport and its Infrastructure	Domestic Waste	To expand the scope of the New Residential Buildings NAMA to achieve higher energy efficiency and GHG mitigation.
9	Harnessing Municipal Waste of big Cities of Pakistan to Generate Electricity	Pakistan	Seeking Support for Preparation	Waste management	**Municipal waste**	**Develop regulatory, legislative and financial instrumental streams for the development and promotion of municipal waste management system and deploying them for energy generation.**

No.	NAMA title	Country	Stage	Sector	Source of Waste	Key Activities
10	Bio-energy generation and greenhouse-gases mitigation through organic waste utilization	Pakistan	Seeking Support for Preparation	Agriculture Waste management	Livestock waste	The primary objective of the project will focus on production of biogas from livestock wastes of dairy farms so as to capture and utilize the CH_4 gas as a source of bio-energy.
11	Reduction, Recycling and Reuse of Solid Waste in Kampala City	Uganda	Seeking Support for Preparation	Waste management	**Municipal waste**	**Reduce waste generation and improve waste collection, recycling and reuse**
12	Integrated Wastewater Treatment for Agro-process Water in Uganda	Uganda	Seeking Support for Preparation	Waste management	Agricultural waste	Increase efficiency and value addition prospects for wastewater treatment of agro-processing firms by establishing an integrated wastewater treatment process using both an anaerobic and aerobic digester with sequencing batch reactor
13	Disposal and Use of Wastes and Solid and Biomass Residues	Mexico	Seeking Support for Preparation	Waste management Energy supply	Industrial waste	Incorporation and compliance to a voluntary environmental program of the Tequila industry for the sustainable disposition of vinazas, bagasse and agave leaf, considered today as a waste.

Source: *http://www4.unfccc.int/sites/nama/SitePages/Home.aspx*

Appendix 12: NAMA in waste sector submitted by developing countries – NAMA database (excluding NAMAs submitted to UNFCCC)

#	NAMA title	Country	Stage	Sector	Source of Waste	Activities
1	Organic Waste NAMA	Chile	Feasibility	Waste	Organic waste	No detailed information
2	Recycling Program NAMA	Colombia	Feasibility	Waste	Solid Waste	Cornerstones of the NAMA are regulatory changes, the promotion of alternative waste treatment technologies, creation of appropriate financial mechanisms, and the integration of informal recyclers into the formal sector.
3	Ordinary Solid Waste NAMA	Costa Rica	Feasibility	Waste	Solid Waste	Methane gas capture and destruction in the three major landfills
4	Integrated Management of Urban and Peri-Urban Solid and Liquid Waste	Gambia	Feasibility	Waste	Urban and Peri-Urban Solid and Liquid Waste	No detailed information
5	Vertically integrated NAMA for solid waste management	Indonesia	Feasibility	Waste	Municipal waste	Integrating policies on GHG reduction in waste sector on local, provincial and national level; Providing a solid foundation to develop mitigation actions in waste sector; Developing the idea of appropriate mitigation actions in solid waste sector by considering local characteristics; Strengthening horizontal and vertical coordination as well as institutional aspect; Building stakeholder capacity and awareness; Supporting international networking and cooperation.
6	City wide mitigation programme of Greater Amman Municipality	Jordan	Feasibility	Waste	**1)Municipal waste** 2)Urban transport 3)Sustainable energy 4)Urban forestry	Financial – financing of investment subsidy and soft loans Investment subsidies, capacity building of municipality staff etc Technical – capacity building support to Greater Amman Municipality, Assistance to the development and the implementation of the MRV system
7	Waste Sector NAMA in Pakistan	Pakistan	Feasibility	Waste	Municipal waste	Integrated Municipal Solid Waste collection, and conversion of Waste to Energy NAMA for Pakistan's cities (includes organic waste separation, recycling, establishment of Waste to Energy Plants and Feed-in-tariff study, electricity generation). 2. Wastewater treatment and Wastewater to Energy NAMA (includes anaerobic treatment, gas separation, organic fertilizer production, electricity generation) 3. Nationwide promotion of both domestic and utility-scale biogas as a NAMA targeting the reduction of GHG emissions resulting from the waste generated from over 60 million cattle and buffalo heads in the country.

#	NAMA title	Country	Stage	Sector	Source of Waste	Activities
8	Solid waste programme	Peru	Feasibility	Waste	Solid Waste	Capacity assessment and Establishing a financeable NAMA programme by increasing private sector engagement
9	Developing a solid waste inventory and identifying NAMA options	Peru	Feasibility	Waste	Solid Waste	Catalyze private investment in methane capture and utilization technology in the waste sector through increased regulation, incentives, capacity building and innovative financing.
10	Revolving Fund for Waste-to-Energy Projects	Philippines	Feasibility	Waste	Municipal Solid Waste Wastewater Cattle and Buffalo Waste	Catalyze private investment in methane capture and utilization technology in the waste sector through increased regulation, incentives, capacity building and innovative financing.
11	Waste and waste water management	Thailand	Feasibility	Waste	Solid and liquid waste	Development of a methodology for planning in the waste management sector
12	NAMA on waste management	Tunisia	Feasibility	Waste	1) Agricultural waste 2)Waste products from food production and sewage sludge	Significant reduction of methane emissions from biodegradable waste
13	NAMA for the sustainable use and disposal of the biomass in Mexico, turning it into renewable energy	Mexico	Feasibility	Waste, Energy supply, Industry	Industrial	Replacement of fossil fuel in the Mexican industry with renewable biofuel derived from the agave, promoting the installation and operation of biomass based cogeneration systems that use agave waste from the Tequila industry.
14	Waste Sector NAMA: Waste to Resources for Cities	Vietnam	Feasibility	Waste	City waste	Building capacities among local partners and the implementation of at least two pilot projects in cities across Vietnam: one in a centrally controlled municipality and the other in a secondary city or small town

Source: http://www.nama-database.org/index.php/Special:RunQuery/QueryData

Appendix 13: Overview: NAMAs in the waste sector

Rating scale for information availability:

Good – supporting documents also available	**Poor** – only overview information available online	**Bad** – (hardly) no information available

NAMAs addressing waste registered in the official UNFCCC NAMA registry:

http://www4.unfccc.int/sites/nama/SitePages/Home.aspx

NAMAs seeking for support for preparation

Country	ID – Title	Outline
Jordan	NS-21 Rehabilitation Of Al-Akaider Landfill	Waste management, carbon capture and storage. http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=14&viewOnly=1
Jordan	NS-28 National appropriate mitigation action (NAMA) for national domestic waste management	National strategy for domestic waste (solid waste and wastewater) management to reduce the greenhouse gases (GHGs) emissions by at least 1 million t CO2 eq annually since according to Jordan's Second National Communication. Domestic waste management from generation to final disposal according to Waste Hierarchy. http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=20&viewOnly=1
Pakistan	NS-139 Harnessing Municipal Waste of big Cities of Pakistan to Generate Electricity	Develop regulatory, legislative and financial instrumental streams for the development and promotion of municipal waste management system and deploying them for energy generation. http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=76&viewOnly=1
Pakistan	NS-147 Bio-energy generation and greenhouse-gases mitigation though organic-waste utilization	The primary objective of the project will focus on production of biogas from livestock wastes of dairy farms so as to capture and utilize the CH_4 gas as a source of bioenergy. Conduct diagnostic studies to evaluate the existing pattern of organic-wastes disposal/utilization and the amount of green-house gases emitted in a time span Management and utilization of bio-digesters' slurry as source of bio-fertilizer to substitute the chemical fertilizer; the main source of greenhouse gases at the stage of manufacturing. http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=81&viewOnly=1

NAMAs seeking for support for preparation

Country	ID – Title	Outline
Uganda	NS-150 Reduction, Recycling and Reuse of Solid Waste in Kampala City	Reduce waste generation and improve waste collection, recycling and reuse. The support will include: training on waste reduction (reducing the amount of municipal solid waste produced by not creating it, through people buying only what they need) and reuse (reusing materials and packaging where possible) and recycling;(materials and packaging that cannot be reused should be recycled) by training on waste handling and how to convert waste into a marketable commodity, support for selling the commodity, maintenance of an information data base on activities for different stakeholders, and a sharing board to create transactions as well as creating a platform for recycling investors as well as solid waste management companies. The NAMA will target the 60 % of solid waste in Kampala that is not collected by the Kampala Capital City Authority (KCCA). http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=84&viewOnly=1
Uganda Wastewater	NS-156 Integrated Wastewater Treatment for Agro-process Water in Uganda	Increase efficiency and value addition prospects for wastewater treatment of agro-processing firms by establishing an integrated wastewater treatment process using both an anaerobic and aerobic digester with sequencing batch reactor. http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForPreparation.aspx?ID=88&viewOnly=1

NAMAs seeking for support for implementation

Country	ID – Title	Outline
Chile	NS-9 National Program for Catalyzing Industrial and Commercial Organic Waste Management in Chile	Catalyse the installation of the first facilities for industrial and commercial organic waste management in Chile (it does not include household organic waste). Contribute to the country´s ability to meet its voluntary commitment to the United Nations to achieve a 20% deviation below the "business-as-usual" emissions growth trajectory by 2020. Installation of approximately five organic waste management facilities (specifically dry fermentation plants that include indoor treatment, power generation or "waste-to-energy" and compost products obtained from the organic treatment process). http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForImplementation.aspx?ID=9&viewOnly=1
Jordan Wastewater	NS-44 The Zarqa River Basin Industrial Waste Water Treatment Plant and Energy Plant(ZIWWTEP)	1,805 MWh of electricity and 506 MWh of usable heat. In addition, the IWWTP should produce in the order of 772,200 m^3 per annum of usable water (not potable). http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForImplementation.aspx?ID=32&viewOnly=1
Dominican Republic	NS-51 Tourism and Waste in the Dominican Republic	Achieve wide spread adoption of alternative energy technologies and address waste management in the tourism sector. Technologies will be based in biomass and solid waste direct firing, combined heat and power, and gasiffiers. The produced steam and/or hot water are used for laundry, swimming pools, kitchens, cooling (via heat exchangers and absortion units). Alternatively, the biomass can fuel a combined heat and power facility, resulting in usable heat and electricity. http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForImplementation.aspx?ID=38&viewOnly=1 and from CCAP here: http://ccap.org/programs/tourism-nama-in-the-dominican-republic/

NAMAs seeking for support for implementation

Country	ID - Title	Outline
Dominican Republic	NS-52 NAMA in Cement/Co-Processing and Waste Sector	Building knowledge of the relevant planning, financing, monitoring (MRV) and communication mechanisms and are enabled to monitor (measure, report and verify) the emissions of green-house gases (GHG) in the waste management and cement production sectors Legal framework and administrative procedure for co-processing waste materials that follow international standards Establish inclusive supply chain of alternative fuel and raw material (AFR) from municipal and industrial wastes to co-processing in the cement production Further benefits of the project are a higher political and financial autonomy from fossil fuel imports, improvement of quality of life for people who live and work close to waste dumps, strengthened public institutions and improved cooperation with the private sector. http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForImplementation.aspx?ID=44&viewOnly=1
Supported NAMAs		
Kazakhstan "All kinds" – not sure where/ how this includes waste	NS – 124 Nationally Appropriate Mitigation Actions for Low-carbon Urban Development in Kazakhstan	The Project supports the identification, design, and implementation of NAMAs in the urban sector. Improve the capacity of municipalities to carry out integrated municipal planning, make targets and prioritize urban mitigation actions. Improve the capacity of municipalities to carry out integrated municipal planning, make targets and prioritize urban mitigation actions (Component 1) Support the creation and strengthening of institutional structures that will allow public and private sector investments in identified infrastructure and technical assistance (Component 2) Provide facilitation of financing of urban NAMA through creation of a dedicated fund (Component 3) Piloting of an urban NAMA in the Prigorodnoye district of Astana through investments in modernization and upgrating of the urban infrastructure (Component 4) Linking the project with the national GHG mitigation efforts, including through standards, rules and procedures for monitoring, reporting and verification (MRV), promoting better information dissemination to stakeholders, and linking the NAMA process with the domestic Emission Trading Scheme (ETS) for industrial emitters Following the NAMA development, the Global Environment Facility will contribute 5.93 million US$ for the implementation of the NAMA.

Additional Waste NAMAs, NOT listed in the official UNFCCC NAMA registry:

NAMA database:
http://www.nama-database.org/index.php/Special:RunQuery/QueryData
provided by Ecofys, last modified in April 2014

NAMAs under development

Country	Title	Outline
Gambia	A)Integrated Management of Urban and Peri-Urban Solid and Liquid Waste	• No detailed information http://www.nama-database.org/index.php/Integrated_Management_of_Urban_and_Peri-Urban_Solid_and_Liquid_Waste
Tunisia	B)NAMA on waste management	• No detailed information http://www.nama-database.org/index.php/NAMA_on_waste_management • Treatment of biowaste from agriculture, food production, restaurants and hotels, sewage and wood waste (according to Global Methane Initiative) – concept stage
Costa Rica	C) Ordinary Solid Waste NAMA	• Methane gas capture and destruction in the three major landfills • Valorization (recycling) of dry materials such as plastics, paper / cardboard, metals and glass • Composting and organic waste biodigestion • Evaluation and implementation of advanced technologies for solid waste management and energy use http://www.nama-database.org/index.php/Ordinary_Solid_Waste_NAMA
Chile	D) Organic Waste NAMA *(not clear if same as NS-9 above)*	• No detailed information in NAMA database http://www.nama-database.org/index.php/Organic_Waste_NAMA but more info here from CCAP: http://ccap.org/programs/industrial-and-municipal-waste-nama-in-chile/
Colombia	E) Recycling Program NAMA	• Cornerstones of the NAMA are regulatory changes, the promotion of alternative waste treatment technologies, creation of appropriate financial mechanisms, and the integration of informal recyclers into the formal sector. http://www.nama-database.org/index.php/Recycling_Program_NAMA more info here from CCAP: http://ccap.org/programs/integrated-solid-waste-management-nama-in-colombia/
Philippines	F) Revolving Fund for Waste-to-Energy Projects	• Catalyze private investment in methane capture and utilization technology in the waste sector through increased regulation, incentives, capacity building and innovative financing. http://www.nama-database.org/index.php/Revolving_Fund_for_Waste-to-Energy_Projects and here (through CCAP): http://ccap.org/resource/philippines-revolving-fund-for-waste-to-energy-projects/

NAMAs under development

Country	Title	Outline
Peru	G) Solid waste programme	• The programme will look at the capacity of existing waste management options for decreasing emissions as well as relevant technical, financial and other barriers to more sustainable use. It will also address the possibility to increase private sector engagement and establishing a financeable NAMA programme. http://www.nama-database.org/index.php/Solid_waste_programme and more info here: http://www.nefco.org/financing/nordic_partnership_initiative and info from CCAP: http://ccap.org/programs/solid-waste-management-nama-in-peru/
Indonesia	H) Vertically integrated NAMA for solid waste management	• Reduce emissions from waste and streamline local, provincial and national level policies in the sector http://www.nama-database.org/index.php/Vertically_integrated_NAMA_for_solid_waste_management and more info here: http://mitigationpartnership.net/bappenas-2013-indonesia%E2%80%99s-framework-nationally-appropriate-mitigation-actions from GIZ V-NAMA project info here: http://www.paklim.org/news-v-nama-project-oct-2013/
Vietnam	I) Waste Sector NAMA: Waste to Resources for Cities	• No detailed information http://www.nama-database.org/index.php/Waste_Sector_NAMA:_Waste_to_Resources_for_Cities (but there is a joint paper for Peru and Vietnam available here: www.nefco.org/files/NOAK-NEFCO_FS_Final_Report_2011-08-08_FINAL_approved_to_NEFCO.pdf) And here (from CCAP financing summit): ccap.org/assets/Vietnam.Thuc.WasteNAMA.pdf

NAMAs subject to feasibility study

Country	Title	Outline
Jordan	J) City wide mitigation programme of Greater Amman Municipality	• Financial – financing of investment subsidy and soft loans • Investment subsidies, capacity building of municipality staff etc • Technical – capacity building support to Greater Amman Municipality, Assistance to the development and the implementation of the MRV system http://www.nama-database.org/index.php/City_wide_mitigation_programme_of_Greater_Amman_Municipality
Peru	K) Developing a solid waste inventory and identifying NAMA options	• Market-readiness preparation for a range of multi-source funded waste-sector NAMAs to achieve waste collection targets, waste disposal targets, recycling targets, waste-to-energy targets and waste management enforcement targets http://www.nama-database.org/index.php/Developing_a_solid_waste_inventory_and_identifying_NAMA_options and report (w Vietnam, same as for (G)) available here: www.nefco.org/files/NOAK-NEFCO_FS_Final_Report_2011-08-08_FINAL_approved_to_NEFCO.pdf
Mexico	L) NAMA for the sustainable use and disposal of the biomass in Mexico, turning it into renewable energy	• Incorporation and compliance to a voluntary environmental program of the Tequila industry for the sustainable disposition of vinazas, bagasse and agave leaf, considered today as a waste. • Replacement of fossil fuel in the Mexican industry with renewable biofuel derived from the agave, promoting the installation and operation of biomass based cogeneration systems that use agave waste from the Tequila industry. • Accreditation of emissions reduction in the production of Tequila through the distinctive "Holohuella CO2" (hologram-carbon footprint) as a physical proof to adhere to the bottle. • In the long term, the NAMA will incorporate to the voluntary environmental program, other biomasses considered a waste besides the Agave. http://www.nama-database.org/index.php/NAMA_for_the_sustainable_use_and_disposal_of_the_biomass_in_Mexico,_turning_it_into_renewable_energy and here from the Global Methane Initiative: https://www.google.com/url?q=https://www.globalmethane.org/expo-docs/canada13/biogas_05_Chavez_Presentation.pdf&sa=U&ei=-suGVJXOBOvV7Aab2IHYAQ&ved=0CAUQFjAA&client=internal-uds-cse&usg=AFQjCNF4GrJIODyAEh3pQPW26iN6JTXj-g
Thailand	M) Waste and waste water management	• Development of a methodology for planning in the waste management sector http://www.nama-database.org/index.php/Waste_and_waste_water_management

UNEP NAMA pipeline:

Provided by UNEP DTU /UNEP Risoe here: http://namapipeline.org/ (xls file used) – the NAMA pipeline mirrors the official UNFCCC database. No relevant additional information.

NAMA Facility:

10 NAMA projects are currently receiving support – none from the waste sector (see http://www.nama-facility.org/start.html).