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Abbreviations and Definitions

BAU	Business As Usual
GEF	Global Environment Facility
GHG	Greenhouse gas
kt	Kilo tonne
Gt	Giga tonne
$MMTCO_2e$	Million metric tonnes of carbon dioxide equivalents
MRV	Measurement, Reporting and Verification
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MSWMS	Municipal Solid Waste Management System
NAMA	Nationally Appropriate Mitigation Action
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Baseline	Development that is expected without initiating any additional action to reduce emissions. The baseline is also referred to as 'business as usual' (BAU), meaning the sum of the current emissions and the anticipated development of emissions over a given period of time (typically a project or programme duration).
Biennial Update Report (BUR)	Reports to be submitted every two years by a developing country providing updated information presented in the county's National Communications, which provide information on greenhouse gas (GHG) inventories, measures to mitigate and to facilitate adequate adaptation to climate change, and any other information that the country deems relevant to the achievement of the objective of the UNFCCC. Least Developing Country Parties and Small Island Developing States have more flexibility. BURs include information on greenhouse gas inventories, mitigation actions taken, and support needs.
International Consultation and Analysis (ICA)	The analysis process of the information submitted in Biennial Update Reports by international experts to ensure completeness, consistency and accuracy of information. It also includes consultations among Parties on the analysis and Biennial Update Reports under the Subsidiary Body of Implementation of the UNFCCC to collectively assess the efforts of countries to address climate change.
Incremental costs	Costs that are over and above those incurred by following the baseline development. The incremental costs are additional ones affiliated with a choice of a lower GHG emission alternative. The term does not indicate which party bears the costs and is only relevant in cases where there is a positive cost affiliated with a deviation from the baseline, not where a deviation is profitable.

Intended Nationally Determined Contributions (INDC)	Parties to the UNFCCC decided at COP 19 in Warsaw to invite all Parties, developed and developing countries, to prepare 'intended nationally determined contributions' (INDC) for the period post-2020. INDC are the contributions of individual countries in addressing climate change in accordance with principles of equity and common but differentiated responsibilities and national circumstances. An agreed element of the INDC is that the cumulative mitigation contribution of all Parties should avoid catastrophic impacts from climate change and ensure a maximum increase of global mean temperature of 2º C by the end of the century.
Measurement, Reporting and Verification (MRV)	Measuring refers to the collection of relevant information to monitor the progress and impacts of a NAMA. Reporting refers to submitting the measured information in a defined and transparent manner. Verification requires independently assessing the information that is submitted for completeness, consistency and reliability. The UNFCCC Subsidiary Body for Scientific and Technical Advice has developed guidelines for measuring, reporting and verification for unilateral NAMAs. Measurement, reporting and verification for internationally supported NAMAs will be guided by the supporters and will follow the guidelines for International Consultation and Analysis adopted at the UNFCCC 17th Conference of the Parties.
Municipal Solid Waste (MSW)	This document will consider the MSW definition given by Hoornweg and Bhada-Tata (2012) in their "What a Waste" report for the Wold Bank, which considers MSW as a mixture of household waste (including hazardous household waste), bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden, street sweepings and municipal services, electronic waste, and market cleansing. This excludes specific hazardous industrial and healthcare wastes. See Annex A for more information about the definition and composition of MSW.
NAMA	Nationally Appropriate Mitigation Action (NAMA) refers to a set of policies and actions that countries undertake as part of their contribution to reduce greenhouse gas emissions. The term recognises that different countries may take different nationally appropriate actions on the basis of equity and in accordance with common but differentiated responsibilities and respective capabilities. It is not legally binding but voluntarily taken by a developing country.
Stakeholders	All persons and institutions that can affect or are affected by a given action, positively or negatively.
Transformational change through NAMAs	It is a change that disrupts established high-carbon pathways, contributes to sustainable development and sustains the impacts of the change. Transformational change is triggered by interventions of actors who innovate low-carbon development models and actions, connect the innovation to day-to-day practice of economies and societies, and convince other actors to apply the innovation. It also overcomes persistent barriers toward the innovated low-carbon development model.
Internationally Supported NAMA	A NAMA that involves contributions from international support in the form of finance, technology or capacity building. Contributions are documented through Biennial Update Reports to the UNFCCC, as per its guidelines in Annex III to Decision 2/CP.17. Developing countries will receive financial and technical support from developed countries for preparation of the Biennial Update Reports.
Unilateral NAMA	A NAMA that does not involve international support and, therefore, is implemented solely with the host country's domestic resources.

1. Introduction

The COP 13 (Conference of the Parties) in Bali (2007) set an important step for developing countries to implement voluntary mitigation actions by introducing the concept of “Nationally Appropriate Mitigation Action” (NAMA) as a mechanism for developing countries to reduce their GHG emissions, while contributing to the achievement of their national sustainable development goals. The Bali action plan emphasised that NAMAs should be in accordance with their capabilities and economic and social conditions, recognising the importance of poverty eradication and social and economic development. The plan also declared that NAMAs should be “supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner…”

Since then, the concept and implementation of NAMAs have been evolving according to countries’ national processes and understanding of NAMAs[1], taking into consideration their emission potentials in main sectors of their economy and national and sectoral development priorities. Currently, approximately 80 NAMAs are registered in the UNFCCC NAMA Registry, and the NAMA database counts more than 150 NAMAs being developed across main sectors in the countries. The top two preferred sectors are energy and transport, while both buildings and waste are in third place. Most of the energy activities focus on biomass, solar, wind, and geothermal.

As it is expected that countries will continue to grow both in population and their economy, the solid waste sector will also continue to grow, especially in urban areas. According to the most recent Emission Gap Report (UNEP, 2014), in 2012 the global GHG emissions amounted to approximately 54 Gt CO_2e, whereas municipal solid waste management (MSWM) accounted for around 5% of the total global GHG emissions (Hoornweg and Bhada-Tata, 2012). The US Environment Protection Agency (EPA) reports that the methane from landfills accounts for 12% of total global methane emissions (EPA 2006, cited by Hoornweg and Bhada-Tata, 2012). Incineration, which is the second most widely used waste disposal practice, is also considered the second largest GHG emissions source of solid waste management activities, generating around 40 MMT-CO_2e (UNEP, 2010). Due to the related emissions and important social and economic impacts, municipal solid waste has become one of the major key aspects of national GHG mitigation policies, especially for developing countries.

Managing solid waste in urban areas is a big challenge, from both environmental and health perspectives. This challenge increases, as the pace of urbanization in developing countries is high. By 2050, urban dwellers will likely account for 64% of the population in developing countries (UNPD, 2012[2]). Inadequate municipal solid waste management system (MSWMS) practices have negative impacts on the quality of life of both urban and rural population. Bad practices of waste management affect the environment, polluting air and water, and therefore have an impact on human health and ecosystems. For example, they can lead to the spread of vector-borne diseases, and mixed waste disposal (municipal waste with hazardous industrial or medical waste) can be extremely harmful for workers in the waste sector, adjacent communities, and the environment[3]. The World Bank (2012) indicated that low-income countries have the lowest collection rates, around 41%. Africa and South Asia present the lowest collection coverage rates, with 46% and 65%, respectively. Therefore, putting in place sound MSW practices is crucial to achieving a sustainable development pathway in developing countries.

The lack of MSWM services leaves a void in handling the available resources that are found in the waste material. This tends to cause the establishment of informal waste activities (called “informal sector”) in developing countries. The informal sector often ensures that a significant proportion of waste is recycled, avoiding the extraction of raw material and processing. This reduces the volume of waste disposed in landfills; water, air and soil pollution; resource consumption and GHG emissions, and, additionally, contributes to job creation by informally employing a considerable number of the poor population. However, while the informal waste sector

1 The overview of the understanding of NAMAs at the national level can be appreciated through their classification by types. The first type is Policy NAMAs, which include long-term comprehensive plan of measures and actions designed to achieve a common goal, and/or government-led programmes that intend to become embodied in legislation. The second type is Projects, where localized capital investments in infrastructure are made with subsequent emissions reductions component.

2 UNEP GEAS web site: http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=105. Accessed 10.04.2015.

3 UNEP Global Partnership on Waste Management web site: http://www.unep.org/gpwm/Background/tabid/56401/Default.aspx. Accessed 10.05.2015.

has positive effects, it also leads to critical environmental and human health impacts, as hazardous waste is not properly handled, and has other social and economic implications, such as poverty, discrimination, child labour, social rejection and lack of education. Therefore, the introduction of adequate MSWMSs can have a significant sustainable development impact on a country while contributing to GHG reductions.

Despite the rising interest in establishing sustainable MSWMSs, developing countries are facing critical problems while trying to implement them. This is mainly due to inefficient policies and legal frameworks regarding waste handling, as well as the absence of clear mechanisms to implement sustainable MSWMSs. Another important factor that prevents developing countries from achieving their waste management goals is the lack of knowledge of waste related topics such as appropriate technologies, management tools, waste issues in the countries, accurate data, and insufficient public awareness regarding the importance of sustainable waste practices. Consequently, developing countries need to design and establish MSWM strategies with policy, legal and financial mechanisms that are appropriate to their waste management challenges, within the social and economic context. These strategies should enable developing countries to mitigate GHG emissions, alleviate further environmental, social and economic challenges, and contribute positively to their national sustainable development goals. Strategies proposed under this framework can be formulated and implemented as NAMAs.

Therefore, MSWM has an enormous potential for developing NAMAs, as addressing sustainable management of MSW not only contributes to sustainable development but also GHG reductions. In fact, 28 cities in Latin America, Africa, Asia, the Middle East and North Africa, North America and Europe have started an initiative for mitigating GHGs and air pollution from the municipal solid waste sector. One main goal of this initiative is to have 150 cities participating in the programme by 2020, with implemented best practice policies and strategies for waste (Climate Initiative Database, 2014). Currently, the NAMA Database lists approximately 16 NAMAs being developing in the field of MSWM (http://www.nama-database.org/index.php/Main_Page, accessed 10.04.2015).

This guidebook attempts to steer countries towards the incorporation of sustainable waste management (SWM) practices into their national low-carbon development plans addressing how these practices can be packaged as Nationally Appropriate Mitigation Actions (NAMAs). It aims to guide governments and policy makers, climate change practitioners, consultants, and other relevant stakeholders through the conceptualization process of a NAMA, providing them with a better understanding of typical MSWM problems and main factors preventing developing countries from achieving sustainability.

This guidebook focuses on MSWM, excluding agricultural waste and hazardous waste from industries and health institutions. To better understand the complexities and technicalities unique to the MSWM, the first chapter explores its main characteristics, social and economic issues, and climate change impacts. In addition, different kinds of MSWM approaches and technology alternatives are presented and assessed with regard to their climate mitigation and sustainability potential.

Chapter 2 gives a generic background on global climate change negotiations, the INDCs (Intended Nationally Determined Contributions) and NAMAs, presenting their origin and founding principles, current interpretations among international stakeholders and the UNFCCC Secretariat, as well as the current linkage between these two concepts.

Chapter 3 describes the main characteristics and particularities of municipal solid waste management systems in developing countries, institutional and legal framework, as well as main issues and challenges of this sector. It describes the stakeholders of the formal and informal waste sector, their roles and how they interact. This chapter also analyses the most common barriers in solid waste management and tries to explain some of the circumstances causing them.

Chapter 4 outlines possible intervention areas for NAMAs on MSWM. Furthermore, this chapter presents some key management aspects and technologies for addressing common barriers of MSWMSs, and their GHG mitigation potential.

Chapter 5 offers an overview of the options to develop a NAMA on sustainable MSWM, based on the information presented in chapters 3 and 4. It outlines goals, scopes, and project boundaries for NAMA projects, describing their possible impacts.

Chapter 6 provides specifics on the measuring, reporting and verification (MRV) of the NAMA impacts, including emissions reductions and co-benefits. While basic requirements are given by the decisions of the Conference of the Parties, current practices in designing and implementing NAMAs show that appropriate

MRV systems designed specifically for the envisioned actions in their specific context are crucial.

Chapter 7 presents some of the existing financing mechanisms for implementing and operating MSWM projects under the NAMA framework. This chapter also includes some practical examples describing main features of waste management projects and their financing approaches.

Chapter 8 summarizes the information contained in this guidebook and offers some conclusions and brief advice on what steps to take in order to tap the potential of NAMAs on sustainable MSWMS.

2. Setting the scene for NAMAs in the new climate agreement and Intended Nationally Determined Contributions (INDCs)

The international response to climate change began with the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, which states its ultimate objective as the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". For over two decades of implementation Parties to Convention were divided into two groups: Annex I[4], and non-Annex I[5] Parties. It is perceived that the distinction between , The parties adhering to the UNFCCC agreed that: *"all Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances,…"* shall *"…Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change …"*. Accordingly, all parties should implement measures to mitigate climate change, with developed countries taking the lead.

During COP 15 in Copenhagen, Denmark, an important political agreement, the Copenhagen Accord, was noted by the Conference of the Parties. The countries that agreed to the Accord recognised the need to hold the increase in global temperature below 2° C, the maximum rise in temperature that science says can be allowed and still maintain the UNFCCC ultimate goal. During COP 15, the NAMA concept was further elaborated upon as developing countries agreed to report their national emissions once every two years via the UNFCCC Secretariat, and that NAMAs would *"be subject to their domestic measurement, reporting and verification"*. During COP 16 in 2010 in Cancun, Mexico, it was agreed that *"developing country Parties will take nationally appropriate mitigation actions… aimed at achieving a deviation in emissions relative to 'business as usual' emissions in 2020"*, and that *"...developed country Parties shall provide enhanced financial, technological and capacity building support"*.

After more than two decades of implementation of the Convention the distinction between developed and developing countries is fading, and the need for enhanced action to reduce emissions is increasing. In fact, the expected outcome of COP 21 in Paris is a new agreement that will define the climate change roles and responsibilities of countries post-2020. A key element of the new agreement will be defining the mitigation responsibilities of the countries, which is central to addressing climate change.

As a preparation for the new agreement, during COP 19 in Warsaw in 2013 countries were requested to prepare and submit intended nationally determined contributions (INDCs). This was done to provide a formal context for countries to express their intended contributions to address climate change, and to provide a basis

4 Developed countries, which have historically contributed the most to climate change.
5 Developing countries with relatively low per capita emissions that are expected to grow to meet their social and development needs.

to discuss the future emission reduction needs and eventual commitments required from countries to be included in the new agreement.

INDCs will define mitigation goals of countries for an agreed commitment period -- either 2020-2025 or 2020-2030. It is expected that developed countries will present mitigation goals as economy-wide emission reduction targets compared to a historic year (e.g. the mitigation contribution proposed by the EU is 40% reduction below 1990 by 2030). In addition to the actions that countries can take to address national GHG emissions, in the case of developing nations, countries may choose to define mitigation goals in two parts: what is feasible for countries to achieve using their own domestic resources, and what more they would be able to do if international capacity, technology and/or financial support is provided. INDCs will potentially also include national climate change adaptation challenges, current and envisioned adaptation actions and support needed to address the adaptation challenges the country is facing.

In the context of the new agreement and the INDCs that countries have committed to submitting, NAMAs could be regarded as a potentially integral part of the contributions countries intend to document to the UNFCCC. Boos et al. (2014) provide an insightful analysis piece on the interrelationship of NAMAs and INDCs. As mentioned, INDCs are mitigation goals defined for a future period and, thus, could be considered as short/medium-term goals for mitigation, while NAMAs can be considered as any mitigation action tailored to the national context, characteristics and capabilities, and embedded in national sustainable development priorities. They can be used for both nationally determined voluntary mitigation actions to address GHG emissions, and specific mitigation actions directed at the sectoral, sub-sectoral or local levels.

NAMAs, as implementation instruments, could translate the short/medium-term goals into implementation plans. For a country that may choose to define economy-wide mitigation goal as INDCs, NAMAs can be seen as implementation plans based on identified mitigation opportunities within various sectors/sub-sectors of the economy. For example, Mexico submitted its INDC as a mitigation goal to reduce GHG emissions by 30% below BAU, by 2030. In defining their mitigation goals, countries would have analysed the mitigation opportunities in context of its sustainable development plans. Therefore, these mitigation opportunities in different sectors and sub-sectors provide the basis for defining NAMAs, to translate goal into an implementation plan. If Mexico, for example, identifies opportunities for GHG emissions reduction in MSWS, it may define NAMAs in this sector as a way of achieving its mitigation goal.

The identification of NAMA actions does not necessarily have to be a top-down process from defined INDC goals at a national level to NAMAs at a sectoral or sub-sectoral level. NAMAs could also be a basis for defining a country's INDCs. In countries where NAMAs have been developed in various sectors and sub-sectors, they can be used to inform the opportunities for mitigation at a national level to structure the country's INDC. Since a key element of the development of a NAMA is an ex-ante, or prior assessment of likely GHG emissions reductions, this information enables countries to assess the total potential GHG mitigation for their commitment period. As NAMAs also provide an assessment of resources required for implementing the actions, the information could help countries identify goals that could be achieved using their own resources, and higher goals that could be achieved through international support.

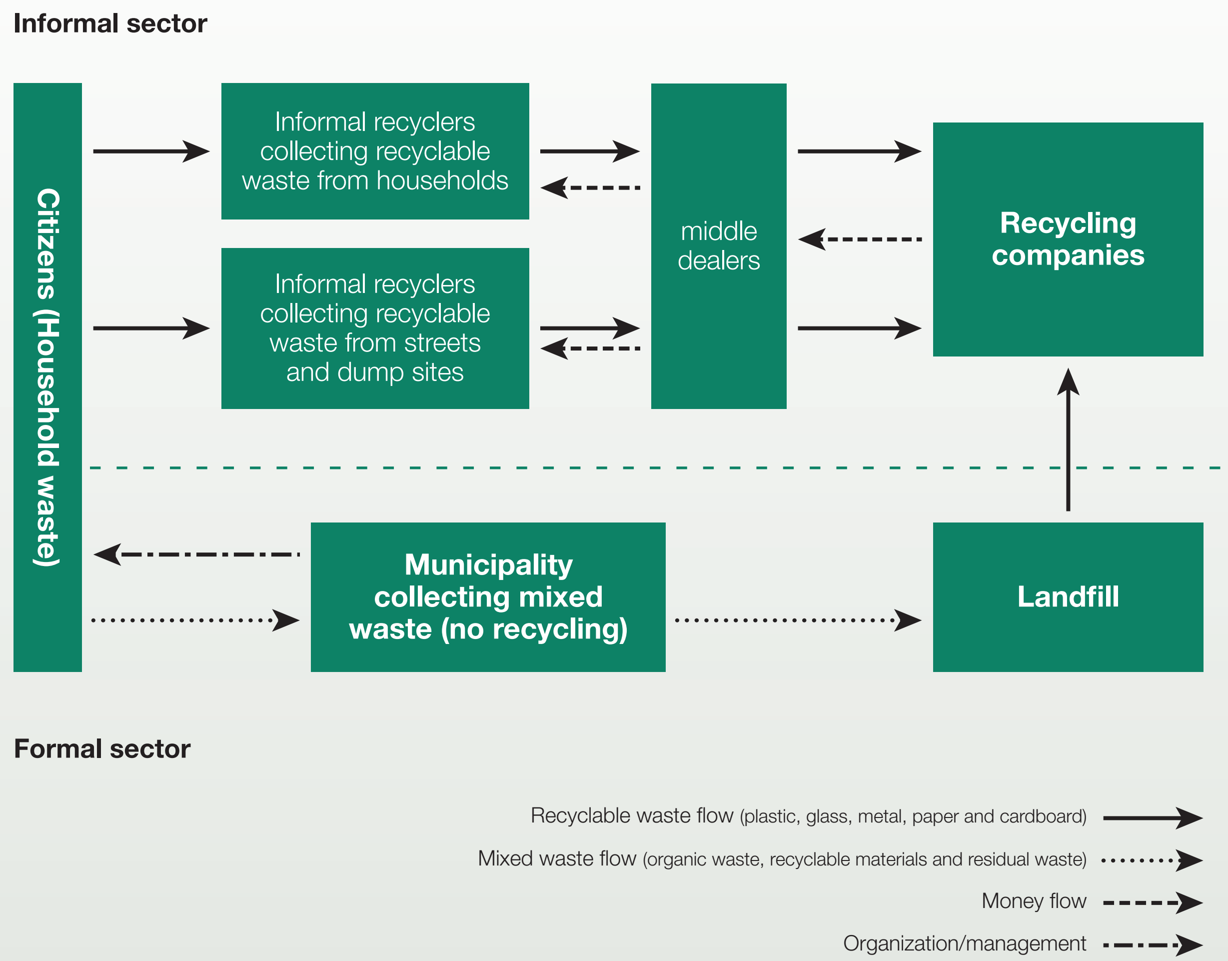
It is important to note, where an INDC already exists NAMAs should be designed in support of them, as the scope of the INDC also defines that of the NAMA. For example, if the INDC of a developing country is to achieve a 50% reduction of emissions in the waste sector, NAMAs could be various elements of action required to achieve the goal.

3. Municipal Solid Waste in developing countries

Municipal Solid Waste Management Systems (MSWMSs) in developing countries

Developing countries have several similarities regarding their municipal solid waste management systems (MSWMSs), which are often inefficient and operate at low standards. For example, the collection rates for domestic waste in countries such as Peru, Paraguay, Uganda and Indonesia are, respectively, 74%, 51%, 30% and 80%, which are significantly low compared with coverage rates in developed countries -- nearly 100% (Hoornweg and Bhada-Tata, 2012). Furthermore, waste management systems in developing countries are commonly based on a single disposal option --landfilling or illegal dumping and incineration-- and are typically operated and managed by local governments, sometimes with support from private waste companies. Other actors – like recyclers (also referred to as waste pickers) – operate at the margins, performing mainly informal waste collection and recycling. Figure 1 presents a flow diagram of a typical waste management system in developing countries, including the informal sector.

Figure 1. Example of a typical Solid Waste Management System (SWMS) in developing countries
(adapted from Aparcana and Salhofer, 2013)



There is a wide range of stakeholders involved in MSWM and they can vary depending on the country and context. Some of the most common stakeholder-groups involved in SWMS are:

- **Households, commercial establishments:** they are essentially waste generators and, at the same time, service users.
- **Local government/municipalities:** they are responsible for the provision of solid waste services. In case of cooperation with private waste companies, the local governments are responsible for the regulation, quality control and verification of services provided by them. Local governments are also responsible for implementing legislation and regulations to ensure sustainable waste services.
- **National government:** they often establish the institutional and legal framework for MSWM, ensuring that local governments have the necessary authority, powers and capacities for effective solid waste management.
- **Private waste service providers:** this group includes a wide range of enterprise types, varying from micro-enterprises to large business establishments. Their main motivation is to generate profits on their investment in waste services. They may cooperate with local governments in several partnership forms.
- **Informal private waste service providers:** known also as "waste pickers", this group encompasses unregulated activities carried out by individuals, groups or small informal enterprises. Their main motivation is to have access to some economic revenue from selling recyclable materials or from collection services in non-accessible or unattended areas.
- **Non-governmental organisations (NGOs):** they primarily facilitate linkage between formal and informal stakeholders aiming to tackle social issues. For example, they can act as provider channel for donor financing, support integration programs for informal recyclers, female empowerment, awareness-raising activities, etc.
- **External Support Agencies:** frequently, external cooperation agencies are engaged in supporting sustainable waste management practices in low-income countries, aimed at tackling possible barriers and constraints that prevent the implementation of sustainable waste management systems. This could encompass know-how and technology transfer, financial aid, etc.

The different roles and interactions between stakeholders is a very important aspect to be analysed and considered for the development and implementation of NAMAs on sustainable MSWM. Having adequate knowledge of stakeholders provides NAMA developers with a fundamental basis for implementing sustainable and transformational NAMAs. Possible synergies and potential cooperation of stakeholders may be used to tackle barriers preventing countries from implementing sustainable waste systems. This guidebook is intended to provide users with a more detailed description of stakeholders, by grouping them into formal and informal sectors, and presenting their main characteristics, problems, roles, and potential for cooperation under the NAMA framework.

Formal waste management sector

As previously mentioned, typical MSWMSs in developing countries are run mainly by municipalities, sometimes supported by private waste service providers. MSWM models often focus on waste removal, giving no economic value to the potential recyclable material. Typical MSWMSs frequently present different technical, financial and efficiency-related problems, such as lack of knowledge about waste technologies or treatment options, inefficient waste fees collection, high waste management costs, lack of appropriate waste infrastructure, etc. These issues can often lead to low waste collection coverage, irregular collection services, open dumping, and burning. For example, the World Bank estimates an average collection rate of 43% and 68% for low and middle-income countries, respectively (Hoornweg and Bhada-Tata, 2012). In these countries, the difference in waste collection coverage among rural and urban areas can be quite high -- from 10% in rural areas to 90% in urban areas (Coffey and Coad, 2010). This problem can be directly associated with negative health and environmental impacts in areas where waste is not collected, but dumped or burned. Dumping untreated solid waste on uncontrolled landfills and open sites is still the most prevalent method in developing countries. A study of 36 urban areas in 22 developing countries showed the common use of open dumps without leachate treatment, gases treatment or other infrastructures needed, while 61% of the analysed cities practiced open burning of waste at the household level (Abarca et al., 2013).

Despite the low efficiency, waste services represent high costs for municipalities. Between 20-50% of the municipal budget is assigned to waste services (Lohri et al., 2014); and 80-90% of this budget is spent on collection and transport (Abarca et al., 2013; Hoornweg and Bhada-Tata, 2012). In addition to high costs, municipalities are confronted with growing amounts of waste (due to increase of population, rising economies) and changing waste compositions, which represent an increase in waste service costs and, with that, the need for more efficient waste management systems becomes more urgent.

Along with the aforementioned issues, municipalities face the citizens' lack of willingness to pay formal waste services. While acknowledging the importance of waste services, often citizens expect low or no cost waste services. This problem is mainly caused by the lack of trust in the ability of local authorities to use the revenue from fees to provide a satisfactory service. For example, considering the data of 16 middle and low-income countries, the average percentage of population using and paying for formal collection service is around 47% (Wilson et al., 2012), and in Sri Lanka, a survey of 1,200 households revealed that only 16% of households with waste collection service were willing to pay for better service (Chandana et al., 2006).

Assuming an unwillingness to pay more, or at all, for better service, the implementation of NAMA on sustainable MSWM represents a difficult but also attractive strategic and technical option for mitigating environmental impacts and solving socioeconomic issues associated with unsustainable waste practices. A NAMA on sustainable MSWM could easily exploit and combine strengths of stakeholders for addressing economic, financial, technological, institutional, and legal barriers. NAMA developers may work, in cooperation with municipalities and formal waste service providers, on the inclusion of strategies for improving and strengthening cost management, and designing finance mechanisms for supporting waste services. A NAMA could generate institutional and legal mechanisms to reinforce the participation of the private sector for tackling technical shortcomings, increasing waste collection rates and increasing the willingness to pay waste fees.

Informal waste management sector

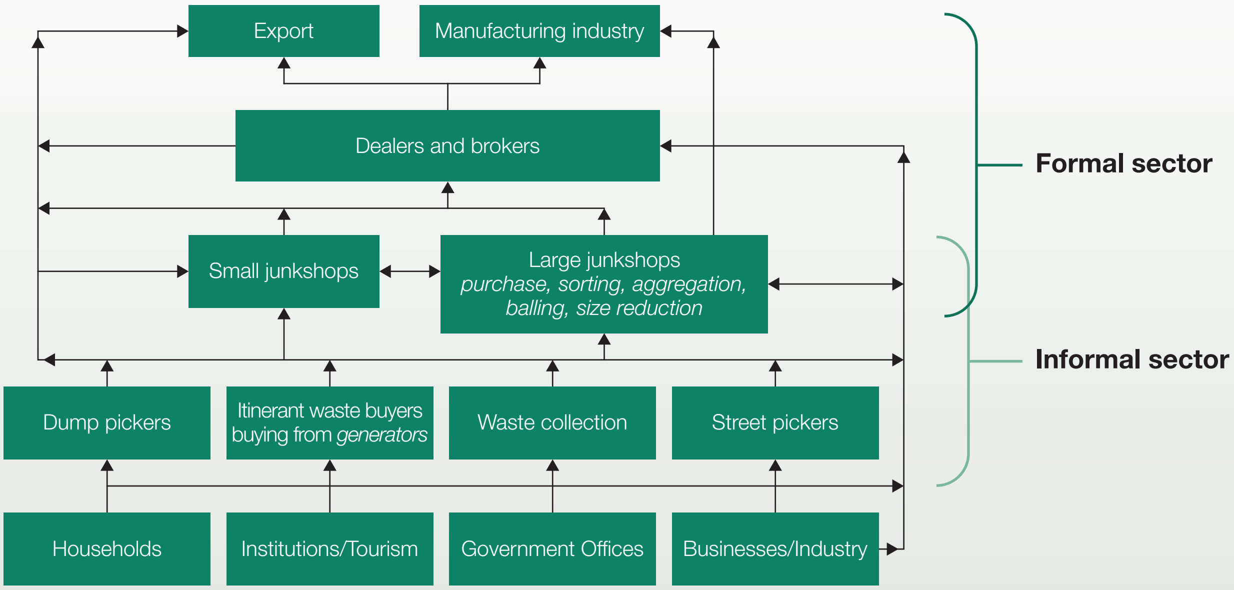
Often, an important part of the waste services in developing countries is performed by the informal sector. This comprises individuals or groups that have no access to formal waste management activities. Informal recyclers often perform waste collection directly from households, waste picking on the street, and finally at dumping places. After picking and sorting, informal recyclers sell the recyclable materials in order to help their livelihood (Scheinberg et al., 2006).

Informal small enterprises or middlemen are better-organised groups. Typically, middle dealers buy recyclable materials from the informal recyclers and sell the materials to waste recycling or waste processing companies. Frequently, they pay informal recyclers very low prices for the materials, which can result in social problems, possible exploitation cycles, and informal recyclers not being able to get out of poverty (Wilson et al., 2006).

Often, the boundary between formal and informal is not always clear. For example, recyclable materials are recovered by informal recyclers, who may sell them to formal recycling companies. Municipal employees, who load waste into municipal trucks, often separate recyclables as they load, and sell what they find unofficially to informal sector dealers. Cooperatives formed by informal sector workers may undertake some (formal) work under contract to a municipal authority while also being involved in informal recycling (Gunsilius et al., 2011). Some of the most typical stakeholders of recycling value chains in developing countries are presented below in Figure 2.

Figure 2. Typical stakeholders of the recycling value chain in developing countries

(Scheinberg et al., 2006)



Despite social problems related to poverty and poor working conditions (e.g. health problems, discrimination, child labour, and poor working and living conditions), informal waste activities contribute significantly to increase recycling rates in developing countries. In some cities, such as Bamako, Mali, informal recyclers carry out up to almost 100% of the total recycling activities. Other examples of cities with an important presence of the informal sector are: Quezon City, the Philippines; Varna, Bulgaria; Delhi, India; Managua, Nicaragua; and Dhaka, Bangladesh (Wilson et al. 2012). These activities also bring important economic savings for the formal sector. Informal collection and recycling reduces the waste amounts to be collected by the formal sector, meaning less labour expenditures, transport, and infrastructure costs for municipalities. For example, informal waste activities avoid costs of approximately EUR 14 million per year in Lima, Peru; EUR 12 million in Cairo, Egypt; and EUR 3.4 million in Quezon City, the Philippines (Gunsilius et al., 2011).

In addition to the economic benefits, the informal sector contributes significantly to the reduction of GHG emissions through resource and energy recovery due to recycling. For example, recycled material is recovered and reintroduced to production processes, resulting in less resource and fossil energy consumption.

Engaging the informal waste sector represents an opportunity for developing NAMAs on sustainable waste management. Countries could develop NAMAs using current informal waste structures, and building on their expertise and skills – e.g. regarding recycling markets, commercialization paths, etc. A NAMA on waste may support the implementation of new waste policies, legal and financial instruments towards formalization of informal recyclers, integrating them into the formal waste system. Integrating the informal recyclers would help countries reach their Low-Carbon Development and sustainability goals related to the waste sector -- e.g. increase of recycling rates and reduction of GHG emissions, job creation, poverty alleviation, etc. Furthermore, appropriate waste management and financial measures should be included for the disposing of waste fractions without a current market value.

Institutional structure and legal framework of MSWMSs

There are three main institutional levels playing different but equally important roles in waste management systems in developing countries: national, regional and local governments. While their roles and tasks may vary depending on the social context, political framework, and other country-related variables, they share important similarities. National governments are responsible for establishing the institutional and legal framework throughout the country. Their main impact on MSWMs often encompasses general policy or strategic decisions, which are reflected in domestic laws, regulations, and standards. This institutional level is responsible for ensuring that regional and local governments have the authority and capacities for the implementation of waste management policies and other waste-related environmental regulations. Often, the responsibilities and tasks at this level are shared by different institutions, such as ministry of environment, national health agency or ministry, and urban development or housing agencies, among others.

The existence of a regional MSWM authority and its role depends strongly on the country's size and political structure. Some countries may not have waste management authorities at the regional level, delegating MSWM to local governments. Regional administrations might be in charge of control finances more so than day-to-day operations. They are more likely to be involved in disposal than collection or recycling, especially where regional disposal facilities are used by several towns and cities (Manus Coffey & Adrian Coad, 2010). Depending on the country, they may also be involved with the protection of regional environmental health and environmental management, or supporting municipalities with the implementation of waste management plants (PAHO-AIDIS-IDB, 2010).

Typically, the local or municipal governments are in charge of the actual implementation and operation of MSWMs. They organise and regulate the system, fees, approval processes, and keep records and data among other activities in accordance with national regulations. Local governments can also perform waste services (sweeping, collection, transport, etc.), however, the participation of the private sector is becoming more common, and private waste companies are also providing diverse waste services. Normally, in such cases, local authorities remain responsible for regulating and controlling the private sectors' activities.

Since national governments define national strategies and policies on waste management, they need to provide local governments with clear steps for implementing these policies, and assist them with this process. In many developing countries, the implementation of policies and regulations is delegated to local authorities without any support or capacity building measures, or in some instances without the finances to secure the enforcement of the policies and regulations. This could lead to wrong interpretations and, therefore, the wrong implementation of national policies and regulations. Here, again, a NAMA on sustainable MSWM could tackle this issue by including well-defined waste policies, standardized regulations, clear institutional structures and responsibilities, and by designing a sustainable financing mechanism for the activities.

Barriers to be addressed in MSWMs in developing countries and their importance for NAMAs

There are several factors or barriers hampering the development of sustainable MSWMSs in developing countries. NAMAs require analyses of these barriers in order to develop appropriate strategies and measures to enable governments to overcome them. Some barriers or factors influence waste systems at the operational level (collection, recycling, etc.) and other barriers have an impact not only at this level but also at the managerial level. The barriers' classification may vary in consonance with the local context, however, they can be primarily grouped into: social, technical, economical, institutional, political/legal and environmental barriers.

Institutional barriers: Problems related to local authorities and their lack of organisational capacities and managerial skills (leadership), departmental or parallel structures and confusion regarding their delineation and distribution.

Policy and legal barriers: Absence of adequate policies and lack of clear legislation, not allowing local authorities and other stakeholders to interpret and implement them properly. Furthermore, there is a lack of verification and enforcement mechanisms, confusion of roles and responsibilities of the relevant national agencies, and lack of coordination.

Economic and finance barriers: Inefficient cost structures, unwillingness or inability to pay for services, budget constraints, untapped revenue streams in the informal sector.

Social and behavioural barriers: Lack of concern for the environment, unwillingness to pay for services, unawareness or non-participation is waste separation activities, social tensions among economic classes between the formal and informal sector.

Technical barriers: Deficient waste equipment and structures (waste transfer stations, old waste vehicles), poor roads, etc. Related to capacity: lack of personnel with technical expertise on solid waste management planning and operation, lack of technical understanding regarding technologies that are not suitable for the local operational conditions -- such as waste characteristics, waste amounts, types, etc. -- unreliable data, and lack of information-sharing between stakeholders regarding technical issues.

In general, when framing a NAMA, the barriers mentioned above should be noted and analysed. When the relevant barriers in the country's specific context have been identified, solutions to overcome them should be proposed. For instance, regarding policy and legal barriers, a NAMA should promote good practices in formulating waste policies, ensuring coherency across specific regulations, enforcement, and verification mechanisms. NAMAs should support the formulation of clear and comprehensive legislation, filling technical, knowledge and enforcement gaps.

The barrier analysis of a NAMA provides the basis for defining the interventions, the activities that form the core of the NAMA, which should solve the problems posed by the barriers. The next chapter will present some strategic and operational approaches that may be included in a NAMA, aiming at removing barriers and allowing the transition to sustainable MSWM.

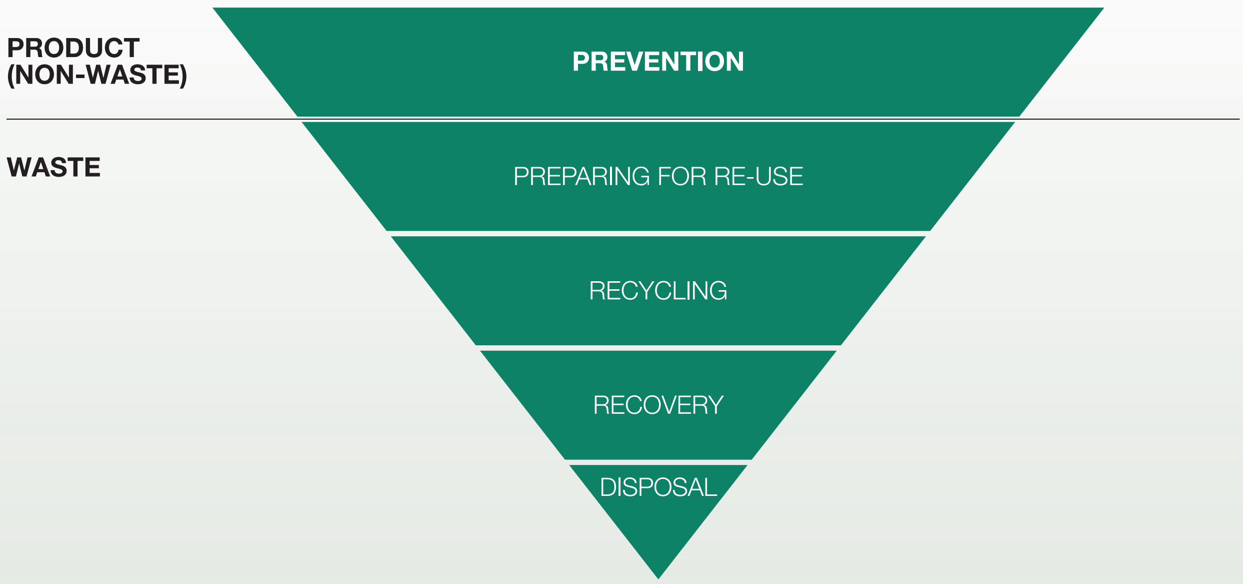
4. Intervention areas of NAMAs on MSWM

This section presents some key management aspects and technologies for addressing common barriers of MSWMSs. Developing a strategy based on the identification of key barriers to transforming MSWM is important in bringing about change. A strategy developed in consultation with all the important stakeholders secures their involvement and compliance, through the addressing of eventual concerns, facilitating the development and implementation of the NAMA. This inclusive strategy serves as a road map and tool to inform all the stakeholders of the change. A strategy also provides the direction for implementation and, thus, a good starting point for developing NAMAs.

As mentioned before, these strategies may be implemented under the NAMA framework, being developed through a consultation process of all stakeholders involved (formal and informal) and taking into consideration the country-related context. Measures towards sustainable MSWM may be applied individually or in different combinations, aiming at using synergies for dealing with key environmental, social and economic problems. Therefore, when formulating a strategy for a NAMA intervention, it is important to enable and support the formulation of clear and comprehensive waste policies and legislation. Considering this, the scope of a NAMA would be to fill the gaps regarding institutional roles and organisation, defining the roles of all stakeholders, as well as addressing the need of technical capacity building. In addition, a NAMA should support waste policies with long-term sustainable goals, leading to transformational changes towards low-carbon pathways in the waste sector. Such fundamental shifts are most likely to succeed if supported by policy or regulatory initiatives. Without embedding initiatives in national legislation, the permanence of the change and, thus, the transformational character of the initiative may be uncertain.

A worldwide waste management concept currently used by many countries is the "3R waste management hierarchy". An abbreviated version of this hierarchy, used as a communication tool, refers to the "3Rs", in order of preference, as: reduce, reuse and recycle (UNEP, 2013). This approach is presently the central pillar of many waste policies, focusing on outlining the

Figure 3. Waste management hierarchy
(European Commission http://ec.europa.eu/environment/waste/framework/)



order of preference of waste management practices towards more sustainable waste systems. The 3R waste hierarchy indicates waste reduction/waste prevention as the most sustainable waste management approach, aiming to decouple waste generation from economic growth -- making it possible for countries to grow, while reducing resource consumption (UNEP, 2010).

There are different variations of the waste management hierarchy but all of them are very similar and focus on preventing waste generation as the first and most important aspect. Waste reuse is placed as the second best option, followed by waste recycling as the third best option. The European Union applies a waste management hierarchy based on five levels: prevention, reuse, recycling, recovery (e.g. energy recovery), and disposal (EU directive 2008/98/EC).

While waste prevention refers to any policy or technical measure to avoid waste generation (e.g. eco-design, extended producer responsibility, etc.), the steps of reuse, recycling, recovery and disposal deal with waste already generated. Reuse implies using products or components for the same purpose for which they were created (EUROSTAT glossary). This could be the reuse of glass bottles for milk, beer, or other drinks. Recycling is defined as the reprocessing of material either for the original purpose or for other purposes -- plastic, paper, etc. (Directive 94/62/EC on packaging waste). Next on the hierarchy is recovery, which comprises energy recovery, organic material recovery (compost), oil refinement, and land treatment, among others (annex IIB to EU Council Directive 75/442/EEC). Landfilling and further final disposal practices are the least sustainable options and, therefore, are at the bottom of the hierarchy.

A NAMA on sustainable MSWM can support waste policies that enable a country to divert waste from one lower step on the waste hierarchy, to the above steps. Examples of these measures include: promoting sustainable use of resources, setting national recycling goals, eco-design for waste prevention, cleaner production, information and awareness programs for waste prevention in households and production facilities, and economic instruments for promoting clean or environmentally friendly purchases. Waste prevention avoids GHG emissions from production activities (extraction of raw materials, energy consumption, etc.), due to less extraction and manufacturing, waste treatment and disposal. For instance, reducing one tonne of MSW at the source could mitigate GHG emissions by 1.3 to 2.5 tonnes CO_2eq/year (OECD, 2012).

While the 3R waste hierarchy is often a central component of national waste policies targeting a definitive transition to sustainable MSWMSs, measures for tackling key barriers can be developed and applied under specific waste management approaches, such as the often-applied “Integrated Sustainable Waste Management (ISWM)”. This approach, developed by the NGO WASTE in the nineties, focuses not only on improving operational aspects (waste collection, transport and disposal), but also on stakeholder participation, waste prevention, and resource recovery measures -- including synergies and interaction at different levels, such as neighbourhoods, cities, etc. As can be seen, ISWM goes beyond the technical level, and focuses on the integration of political and social factors, as well as other interrelated processes into the waste strategy, which makes it a tool that fits well with the general broad scope of NAMAs. Text box 1 shows an example of the development and implementation process of ISWM in Kenya.

Text box 1. Example of an ISWM
(Mwanzia et al., 2013)

Case study on ISWM: decentralised service delivery in Nakuru, Kenya

Nakuru city is the fourth largest urban centre in Kenya, with a total population of 473,000 (census 2009) and a population growth rate of around 13% per year. Nakuru generates approximately 250 tonnes of waste/day, and in 2006, the collection rate amounted to 30% of the total generated waste. Until the year 2006, the waste system was entirely run by the municipality, which had only enough resources to serve the Central Business District and some high-income residential areas. There was some participation of private companies that also collected waste from high-income areas in the town. However, these activities were not regulated, and operated outside the municipality control. In low-income neighbourhoods, waste was either dumped in the streets, or collected by a few informal recyclers. Extremely poor waste recyclers recycled a small portion of waste at open dumps and in streets.

In 2006, the Nakuru environmental management by-laws were brought into force, providing the possibility of decentralised service delivery for municipal waste collection, transport and final disposal at the municipal refuse site. The new by-laws allowed three categories for waste service providers: 1) community-based organisations, 2) private waste handlers, and 3) municipal council services. As part of this new waste regulation, the municipality organised seminars, workshops, and training for stakeholders to create awareness about solid waste management, and ensure compliance by residents and the licensed organisations. In addition to the municipality's activities, the international NGO "Practical Action" implemented two projects aimed at improving the environment in low-income settlements and increasing incomes for those who could be involved in the enterprises. The NGO collaborated with local community groups and medium-sized private enterprises, in order to develop waste service approaches according to the market conditions. Further stakeholders involved in these projects were the municipality as a regulation actor, the Nakuru Housing and Environmental Cooperative Society (NAHECO), the Community Savings and Credit Cooperative (SACCO) for provision of small-scale investment funds for waste enterprises, and the Family Bank (a local bank for higher investments financing waste enterprises).

The results of this initiative were: 1) the increase of the waste collection rate from 30% to 64% due to the creation of 24 waste service providers (community-based organisations and private waste enterprises), 2) the increase of the recycling rate to 19% of the total generated waste, 3) effective application of the "user pay principle", where households and institutions pay fees for collection services directly to the service provider, supporting the economic sustainability of the decentralised service, unlike before when the service was free through the municipality, 4) the municipality plays only a monitoring role, while local waste enterprises provide the service, meaning reduction of waste management costs, and 5) sustainable development of the community through creation of local added value and allowing the citizens to become self-sufficient service providers (Mwanzia et al., 2013).

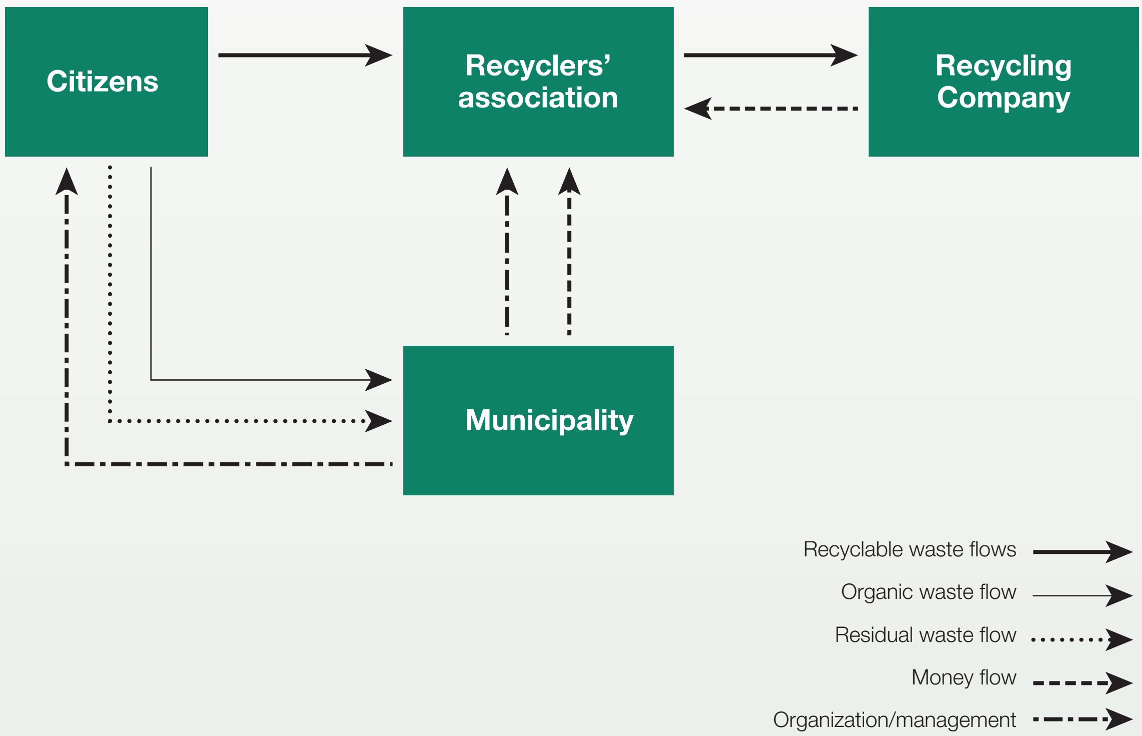
As mentioned earlier, NAMAs on MSWM can be built on national waste strategies that support the implementation of new waste policies, legal, and financial instruments towards formalization of informal recyclers, integrating them into the formal waste system. Over the last years several formalization approaches have been implemented in order to improve waste management systems and transform them into more socially inclusive systems. Some examples of successful experiences can be found in Mumbai (India), Manila (the Philippines), Londrina and Diadema (Brazil), Bogota (Colombia), Cañete (Peru), among others (Wilson et al., 2009; UN-HABITAT 2010; Gutberlet, 2011; Mahadevia et al. 2005; Terraza and Sturzenegger 2010). Text box 2 presents a case study of formalization measures implemented at the policy level.

Text box 2. Example of formalization in Brazil

Formalization: case study in Londrina, Brazil

Londrina's case is interesting in relation to the recycling efficiency and the operation of a selective waste collection system based on the cooperation between formalized recyclers and the municipality. Londrina is a city in Parana, Brazil and has a population of approximately 500,000 inhabitants.

Since 2001, the municipal system changed by allowing informal recyclers to participate in the waste management system as a formal stakeholder. This new waste management concept implemented a remuneration system for the separate waste collection done by the recyclers based on the served area and not on the mass (tonnes) of collected total waste. By the year 2009 there were 33 associations working and representing 400 recyclers – with a female participation of 80%. The following figure describes the formalization system in Londrina:



In 2011 this participation increased to 500 formalized recyclers producing 274 t of recycled materials/month, recovering about 26.6% of the household waste. In order to strengthen the bargaining position of the recyclers' associations and to achieve better material sale prices, a main storage and sales centre was created. With this measure, higher sales prices and higher average incomes have been achieved (230 USD/month).

Thanks to this formalization policy, the waste management costs for the residual waste has been reduced due to the increase of the separate collected waste volumes -- from 42 USD/tonne collected waste in 2001, to 24 USD/tonne collected waste in 2003.

This recycling programme in Londrina has brought not only environmental and economic benefits but also positive social impacts. Some environmental benefits are the reduction of landfill volume, resources recovery through recycling, etc. The positive social impacts include improvement of living and working conditions for recyclers, achievement of their economic stability and empowerment by means of the creation of associations, the recognition and support of their activities by the population and local authorities (Gutberlet, 2011; Terraza and Sturzenegger, 2010; Gomes do Reis et al., 2005).

In conclusion, waste management policies developed under the NAMA framework should have the 3R waste hierarchy as their core principle, and should consider formalization measures, according to the local socio-economic context and stakeholders. Some measures that could be derived from a 3R-based waste policy and included in a NAMA, are:

Institutional measures:

- Capacity building moving towards improving organisational capacities and managerial skills (leadership).
- Establishment of clear organisational structures, coordination and communication channels and procedures among public institutions of the waste sector and others related.
- Clear definition of tasks and responsibilities, and interaction across the waste public sector, in order to avoid confusion.

Policy and legal measures:

- National goal of increasing waste collection and recycling rates.
- Favourable national policies, regulations, political support, law enforcement.
- National policy supporting waste prevention strategies, such as eco-efficiency: packaging reduction, producer responsibility.
- Integration of the informal sector (formalization), which is a very important step to generate a social inclusive waste management system.
- Promotion of community engagement in local waste management systems. There are some examples of successful public participation in MSWMSs developing countries, such as in Brazil, India, and the Philippines, where national policies and legal frameworks support these initiatives.

Economic and finance measures:

- Integration of the private sector in the operation of waste services, as a tool for improving the efficiency of MSWMSs and reducing management costs. These are considered typical private sector companies and formalized recyclers (ex-informal sector).
- Rethinking of waste tariff systems for creating a sustainable finance waste structure that is adapted to the local contexts and needs (for example, adapted to income levels, type or user, amount of waste, setting fees with assistance of community organisations, etc.).
- Reorganisation of fee collection mechanisms, for example, by operators or respected community members rather than by the government.
- Community involvement as a way for financing waste services in marginal areas in developing countries. For example, UNEP (2005) suggests the participation of citizens in performing waste services voluntarily. This way, the cost of waste services can be kept at an affordable level.
- Another option would be to encourage citizens to form local micro-enterprises for providing waste services. Under this scheme, the residents of the area served by the micro-enterprises would pay the collection costs.
- Development of local and national recycling markets. The valorisation of recyclable materials would be one way to create a sustainable strong economic and social basis for MSWMSs.

Social and behavioural measures:

- Raising public awareness regarding information and education campaigns for citizens.
- Training and empowerment of formalized recyclers.

Technical and capacity measures:

- Implementation of separation at source system.
- Use of appropriate local technologies for waste treatment.
- Upgrading of landfills and elimination of dumping sites.
- Assessing and documenting existing SWM systems, accurate data collection.
- Technical/operational requirements: access to adequate sorting spaces, infrastructure, topography considerations, improve quality of secondary raw materials.

Appropriate technological options for NAMAs on MSWM

NAMAs on waste management include strategic policy oriented measures that enable, among others, the adoption of environmentally sound technologies and processes. A NAMA on waste management may also be developed targeting a specific technology option for the operational aspects of waste processes, such as recycling, collection, treatment or even landfilling. In order to ensure a sustainable and transformational transition, a NAMA may include capacity building and technology transfer objectives, aiming at tackling barriers related to these aspects.

There are several technical approaches that can be included in a NAMA on waste management at the operational level. Their inclusion in national waste policies or waste strategies should be considered taking into account the country-specific socioeconomic context, as well as specific conditions and requirements related to the waste to be treated. This chapter presents some general features of waste technological approaches, and the role they could play in the mitigation of GHG emissions under the NAMA framework.

Recycling

Recycling is, after waste prevention, the most promising waste practice towards GHG mitigation. Recycled materials may be reintroduced into production chains in different ways. They can be used for partially or entirely replacing raw materials within the same product (closed loop recycling) or they can replace raw materials of a new or different product (open loop recycling). Recycling can also be carried out at a broader level, such as the circular economy approach, where industries may exchange materials and energy to improve resource consumption, save costs and reduce emissions.

Recycling contributes to GHG mitigation by avoiding the emissions linked to the use of raw materials. These emissions are caused by the energy and resource consumption needed for the extraction and processing of raw materials. For example, recycling paper avoids the use of virgin wood, which depending on the scenario can be used as fuel replacing fossil fuels or can be left in the forest for carbon sequestration. The OECD (2012) indicates that each additional tonne of municipal solid waste diverted to recycling reduces GHG emissions by 1.3 to 2.7 tonnes CO_2e.

The mitigation potential of recycling activities in developing countries, which are mostly informal, has been also widely estimated. For example, informal recycling of paper, plastics, metals and glass in Delhi, India, represents an emission reduction of approximately 962,000 tonnes CO_2e/year (Chitan Report, 2009). Further, the recycling activities in six different cities in developing countries (Peru, India, Egypt, Romania, Zambia and the Philippines) save around 496,700 tonnes CO_2e (Scheinberg et al., 2010). As previously mentioned, a NAMA on sustainable MSWM may support the formulation of waste policies and strategies towards the integration of the informal sector, aiming at increasing recycling and collection rates, as well as removing social and economic barriers to sustainable waste management systems.

Composting

Composting is a controlled aerobic biodegradation process to treat organic waste. The main output of this process is called "compost" and is used as organic fertiliser. Composting waste helps to avoid methane emissions linked with inappropriate disposal of untreated organic matter. The inputs that are typically composted are food waste, agricultural waste, and the organic fraction of industrial and municipal wastes.

The compost is a very nutrient-rich organic fertiliser, which can be used instead of chemical fertilisers. Using compost as fertiliser has a number of benefits: it reduces soil erosion, improves soil structure, facilitating water and air transport in the soil and pH stabilization among others.

Composting of organic waste contributes to GHG mitigation mainly through avoided methane emissions of unappropriated disposal of untreated organic matter, as well as the substitution of chemical fertilisers, which are produced from raw resources. The substitution of chemical fertilisers represents GHG savings of around 8 kg CO_2e/tonne of composted waste (UNEP, 2010). Moreover, compost may also act as a carbon stock – high-carbon storage capacity, due to slow carbon mineralisation process. Some composting NAMA projects for reducing GHG emissions from waste can be found in the NAMA Database (http://www.nama-database.org).

Composting is one of the most applied technologies to treat organic waste in developing countries. It is a technologically and economically accessible option that simultaneously generates aggregated economic value to organic waste. In fact, several countries have successfully implemented composting as a strategy to treat the organic fraction of municipal solid waste -- e.g. Mumbai, Delhi (India), Dhaka (Bangladesh). These initiatives are based on source waste separation at the household level and incorporate training and awareness programmes for the community, aiming to improve source separation and produce high quality compost. It is widely known that high quality source separation reduces contamination of compost and, therefore, increases its quality. Compost from mixed waste may contain small quantities of chemicals, heavy metals, plastic, glass and other materials.

In India, 9% of the total MSW is separated, composted and used in the Indian fertiliser market (UNEP, 2010), with approximately 200 tonnes/day of source separated organic waste being composted in Delhi alone. In Dhaka, Bangladesh, an NGO called Waste Concern has produced 300 tonnes of compost/year and has sold it in rural areas of Bangladesh (UN-HABITAT, 2010). One main characteristic shared by these experiences is the existence of strong local fertiliser markets, including the demand for compost, and growing agricultural activities. A NAMA on waste management may take advantage of such socioeconomic context and use it to design suitable waste strategies and technological options.

Anaerobic digestion

Anaerobic digestion (AD) consists of a microbiological biodegradation process that occurs normally in absence of oxygen. This process occurs naturally in lakes and swamps, as well as other situations where organic material biodegrades in the absence of oxygen, can be applied to any organic material (with the exception of high lignin/woody content materials), and produces methane as a by-product. Controlled AD can be performed with the appropriate technology, where organic waste is used as input and the methane is collected for utilisation. Depending on the input's quality, waste composition, and the state of technology, the biogas generated can reach high methane contents. For example, organic waste from source separation (green waste bins) and markets may produce gas with a high yield of methane of around 60% (Institut für Energetik und Umwelt gGmbH, 2006; Bayerisches Landesamt für Umwelt, 2007).

Biogas has a number of uses. Typically, small-scale biogas plants in developing countries convert it into heat and use this energy for cooking, heating, drying of grains, etc. However, plants with a more complex technology can generate electricity and heat through cogeneration. Small-scale biogas plants are more frequent in developing countries, due to their easy-to-implement technology and low construction and operation costs. Frequently, small biodigesters treat animal and human manure, waste water, and small quantities of solid household waste. These kinds of projects aim to decentralise solid waste treatment systems, making them available for people living in rural or isolated areas. The AD process also occurs in existing landfills, producing "landfill gas", which is constituted mainly by methane. This can be captured and used for energy recovery, or flared. This will be described further in the section on landfills.

The GHG mitigation potential of AD may vary depending on the end use of the energy (gas, electricity, heat, transport), local electrical or energy grids, technology, etc. High-tech biogas plants in Europe may have a net climate impact ranging from -375 to 111 kg CO_2e per tonne of wet organic waste input (UNEP, 2010). As mentioned above, Chile and Dominican Republic are implementing NAMA projects on AD, aiming to avoid GHG emissions from commercial and industrial waste. As a result, it is expected to achieve an accumulated reduction of around 51 $MMTCO_2$e in 20 years (http://namapipeline.org/). Countries such as Dominican Republic, Pakistan, Chile and Uganda are developing NAMAs for waste treatment using anaerobic digestion (http://namapipeline.org/).

Waste incineration for energy recovery

Incineration is one of the most used thermal waste treatments around the world. While this technology is widely applied in developed countries, its implementation is still low in developing countries. However, some developing countries are changing their waste management systems and legislations, giving place to the incorporation of incineration as standard waste practice. For example, there were 12 WtE (Waste to Energy) projects planned to be implemented in Brazil in 2010, almost all of which being public-private partnership (PPP) projects (Gutberlet, 2011).

However, before considering incineration as the technical approach of a NAMA, the socioeconomic context, as well as certain technical requirements related to the type of waste, should be analysed. For example, negative socioeconomic impacts may come up when incineration is performed instead of formalized recycling (e.g. decrease of jobs and income sources). Moreover, environmental issues may arise in cases where incineration is performed without appropriate air pollution control systems. Technologically appropriate incineration uses temperature and air pollution control systems, which help to reduce or avoid emissions of NOx, SOs, dioxins, furans, and other substances related to incineration processes. Nevertheless, even if the incineration is performed with air pollution control, the generation of hazardous residual incineration wastes still represents an environmental problem, with additional costs for landfilling such materials.

Dry municipal waste can be used as the only fuel for the process or it can also be used as complementary fuel in co-incineration (e.g. cement kilns). Principally, incineration can save GHG emissions through energy recovery -- electricity and heat. This energy can be used for replacing energy generated by raw fossil fuels, saving GHG emissions related to their extraction and processing. For example, a UNEP report on waste and climate change (2010) mentions a mitigation potential between 480 and 712 kgCO_2e/tonne waste -- considering European waste composition, 15-30% electrical efficiency, and 60-85% of heat conversion.

It is important to consider that most developing countries do not meet the required pre-conditions regarding quality and composition of municipal waste that would ensure an appropriate incineration. Typically, developing countries generate MSW with high organic waste contents -- around 64% for low-income countries and 54% for upper middle-income countries -- and low heating value (3.3-4.6 MJ/kg waste); characteristics that make solid waste difficult to burn. Therefore, before considering incineration as the main technological option for a NAMA on MSWM, technical, logistical and economic aspects should be taken into account -- e.g. type of waste material, calorific value, chemical composition, current treatment and commercialization channels, etc. For instance, AD might be a more appropriated technical approach for municipal waste with high organic matter content.

Nevertheless, there are some successful co-incineration projects, use of pre-treated waste as refuse derived fuel for replacing fossil fuels in conventional industrial processes such as cement kilns, in developing countries. For example, the private cement company Holcim Ltd and the German-based international cooperation enterprise Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) initiated a public-private partnership (PPP) aimed at improving waste management in 20 selected developing countries. In Chile, for example, the Holcim's Polpaico cement plant achieved a CO_2eq reduction of 8.9%, compared to waste disposal without gas collection, only through the substitution of 20% of fuel with waste (Holcim Ltd and GIZ, 2009).

Landfilling

As already outlined in the previous chapters, open waste dumping and landfilling are among the most common waste practices in developing countries, and are the largest contributors to GHG emissions from the waste sector. However, using landfill gas for energy recovery compensates emissions in favour of GHG emission reductions. Landfill gas contains around 50% methane and can be captured and burned in CHP units for generating electricity and heat.

Regarding the mitigation potential, UNEP (2010) mentions an emission reduction potential of 5 to 140 kg-CO_2e/tonne of MSW -- assuming for this calculation the European waste composition, LFG capture efficiency of 50-80%, and 48% of the original biogenic carbon stored. More practical examples of cities implementing NAMAs with energy recovery systems in landfill sites can be found in Table 2.

5. NAMA options for sustainable MSWMSs in developing countries

The key to designing a NAMA in MSWS is to ensure that the activities are sustainable and replicated to get maximum national, as well as climate change, benefits. This would involve identifying the factors/barriers to bringing change in the sector and developing a comprehensive strategy.

This includes an evaluation of the institutional and legal context, and analysis of stakeholders and stakeholder behaviour conducted prior to NAMA design. The context and background should include a description of the current level of, and approach to, sustainable waste management practices. Relevant national policies, objectives, and laws are the foundation for this assessment, such as waste management policies, existing recycling and disposal rate goals, waste treatment regulations and requirements, and national climate change policy and targets, including low-carbon development strategies. This information serves as both a baseline (starting point of the NAMA) and a foundation for integrating the actions into national policy.

In recent years, the UNEP DTU Partnership has published a number of guidebooks that outline how to structure and formulate NAMAs -- e.g. Understanding the NAMA Cycle, Guidebook for the development of a NAMA on efficient lighting, among others. Different important aspects to be considered during the development and implementation of NAMAs are described and analysed in those guidelines.[6] Therefore, the present chapter will not focus on the general structure or consideration of NAMAs, but will present the different NAMA options and their scopes, which can be proposed and developed for addressing current MSWM issues in developing countries. Before formulating the objectives and scope of a NAMA, it is important to know the main characteristics of the waste system, considering policy and legal framework (e.g. legal definition of municipal waste in the country), institutional organisation, geographic scope (national or local), stakeholders and their roles, technologies, mail elements of the waste management system (collection, recycling, treatment and disposal), and further operational aspects, as well as the socioeconomic context. Due to the fact that MSWMS in developing countries are characterised by many strong social and economic issues, it is important to consider them alongside the environmental ones. The NAMA options described in this chapter are suggested based on the issues and challenges of MSWMS and their possible intervention areas (management approaches and technologies), pointed out in Chapter 4.

Identification of possible NAMAs on MSWMSs

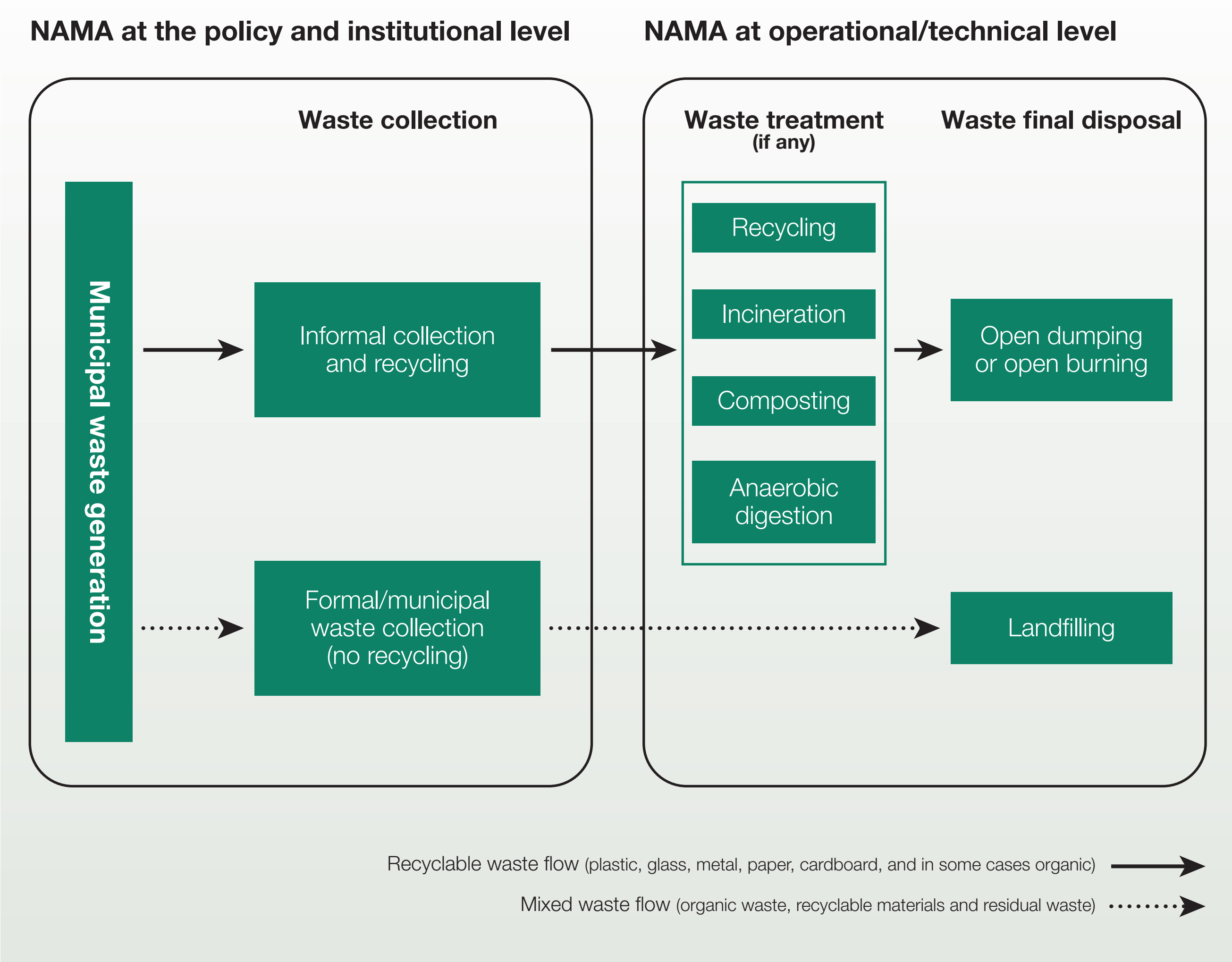
The most common objective of a NAMA on sustainable MSWM is to implement sustainable waste management practices, reducing GHG emissions and contributing to the sustainable development of the country. Typically, it is expected that the scope and objectives of a NAMA refer to high level policy objectives related to the national climate change and low-carbon development path, thus contributing to both national sustainable development goals and greenhouse gas emissions reduction targets. Additionally, a NAMA on waste management may address other objectives not directly related to climate change -- e.g. reducing demand for resources or achieving social inclusion in the waste sector, social and environmental awareness, public health, etc.

A NAMA on sustainable MSWM may be formulated at the project level, addressing more specific issues related to operational waste management elements, such as technology access, waste facilities, and reorganisation of waste systems and waste flows, among others. In order to achieve a transformational change of current MSWM towards more sustainable systems, a NAMA on MSWM should aim to achieve permanent changes through policy initiatives, strategies or regulations that include sustainable management approaches -- NAMA on MSWM at the policy/strategy level. Re-

6 For more information on general structure and formulation of NAMAs, please visit the UNEP DTU Partnership web site: http://www.unepdtu.org/PUBLICATIONS/NAMA-Publications

gardless of what kind of waste management approach is implemented, a NAMA should consider including key legal, financial, institutional and/or technical measures that support and ensure the implementation of sustainable and socially inclusive waste practices. Figure 4 shows the waste system elements that may be included in a NAMA according to its level of intervention. For example, to take action on waste generation, collection and recycling requires work at the policy and legal level -- including the 3R hierarchy, separation at source policies (waste generation) or formalization of recyclers and their inclusion into the formal waste management (collection and recycling). Measures such as the upgrading of open dumps to landfills or installation of gas collection and flaring systems can be found in operation-oriented NAMAs at the project level, and involve taking actions on waste treatment and final disposal phases.

Figure 4. Waste system elements encompassed in NAMAs



It is important to highlight that NAMAs are not limited to just one of both scopes. A policy/strategy oriented NAMA may lead to the formulation and implementation of NAMAs at the project level. Table 1 shows some general examples of possible points for NAMA actions at the policy/strategy and project level.

Table 1. Possible NAMA actions

Action level	Description	Examples
Policy/strategy	Establishment of national waste management goals Favourable national regulations; enforcement mechanisms; including microcredit initiatives, financial incentives National policy on formalization of illegal waste activities	x% reduction of CO_2 emissions from the waste sector x% increase of renewable energy from waste x% increase of national recycling rate x% decrease of waste volume diverted to landfills National adoption of 3Rs waste hierarchy Organisation of the informal sector, formation of cooperatives/micro- and small-enterprises, and associations
Project (technological/ operational)	Focus on infrastructure Reorganisation of waste elements (collection, treatment, disposal) Upgrading of waste facilities and technologies	Pilot projects Adequate sorting spaces, infrastructure, topography considerations, improve quality of secondary raw materials Implementation of source separation systems Appropriate technology, economic and technical assistance Implementation of gas collection and flaring system or energy recovery from landfill gas

Text box 3. Identifying the Appropriate Actions in the waste sector in Colombia

(CCAP, 2013)

Identifying Appropriate Actions in the waste sector in Colombia

Colombia has designed a NAMA concept for the waste sector, seeking support for implementation. The NAMA is aimed at overcoming existing policy, financial, market and social barriers for the introduction of alternatives to landfill disposal. Through the NAMA, the Colombian government aims to promote alternative waste treatment technologies and the integration of informal recyclers into the formal sector.

A pre-feasibility study was conducted as part of the NAMA design process, where it was found that not all technologies are suitable for Colombia. For example, due to the availability of cheap electricity in Colombia (much of it generated by large hydroelectric plants), many solid waste technology options will need to focus on alternatives that do not compete with grid-connected electricity generation. Therefore, Mechanical Biological Treatment (MBT), which allows material recovery as well as biological treatment of the organic content, is more suitable in the Colombian context rather than using the waste for electricity generation.

The NAMA consists of actions both at the project and policy level, including key legal, financial, institutional and/or technical measures that support and ensure the implementation of sustainable waste practices.

The Solid Waste NAMA is a combination of unilateral and supported actions that include:

- Regulatory and policy reform: aimed at reforming the waste handling tariff to create a strong incentive for the involvement of the private sector to shift from landfill to alternative treatment methods such as recycling, composting and production of Refuse-Derived Fuel.
- Promotion of alternative waste management technologies and waste management treatment processes: the Colombian cement industry, which is currently using natural gas and coal in its cement kilns, is a potential market for Refuse-Derived Fuel produced by alternative waste treatment facilities, which would partially substitute fossil fuels. Discussions held with the three largest cement producers indicate that Refuse-Derived Fuel could have a ready market in many of their plants by substituting fossil fuels in their cement kilns.

- Establishment of a fund and innovative financing mechanisms: a NAMA Equity Fund has been proposed to finance alternative waste treatment facilities in order to facilitate their financial feasibility and reduce the risk perception of the private sector.
- National and subnational capacity building activities: the envisioned actions are the implementation of the waste source separation policy, awareness and education programmes, and the formalization of informal waste pickers.
- City-level action for integrated waste management policies: some cities are already designing a source separation policy. However, it is important to increase the quality of recyclables taken from the waste stream, as well as the quality of compost produced from organic waste. These policies are optimal from the GHG perspective and should be integrated within the NAMA whenever possible. Public awareness and education programmes at the national and city-level will be designed to promote waste separation into different fractions in households. Awareness programmes designed to educate the population about the benefits of recycling, composting, etc. is of special importance to allow the production of high quality recyclables, compost and Refuse-Derived Fuel (CCAP, 2013).

NAMAs should result in transformational change by shifting the market towards a low-carbon pathway on a permanent basis. That fundamentally means that interventions are generally without an end date. Exceptions to this rule are short-term technology oriented NAMAs that would have the objective to renovate or improve inefficient waste facilities or installations. An example could be the installation of landfill gas and leachate collection systems in controlled dumps, or the elimination of open dumpsites. Such measures have an end date to encourage a quick elimination of environmental or health problems.

Table 2 presents some examples of NAMA on MSWM that are under development or at the feasibility study stage. These are based on information about NAMA related activities, and do not solely represent official submissions. As can be observed, there are a number of possibilities for formulating NAMAs on MSWM, ranging from policy/strategy NAMAs to basic technology oriented NAMAs. Sometimes the implementation of a new technology or new management alternative requires taking actions at the high policy level. This may combine both approaches.

Table 2. Examples of NAMAs on MSWM

(adapted from NAMA Database http://www.nama-database.org/index.php/Main_Page)

Name	Country	Objective	Action level	Main measures taken	Submitted to the UNFCCC Registry
City-Wide Mitigation Programme of Greater Amman Municipality	Jordan	Reduction of emissions from municipal waste, urban transport, sustainable energy, and urban forestry estimated to average around 560 ktCO_2e per year.	National policy/ strategy	• Financing of investment subsidy and soft loans • Investment subsidies • Capacity building of municipality staff • Capacity building support to Greater Amman Municipality • Assistance to the development and implementation of the MRV system	No
Developing a Solid Waste Inventory and Identifying NAMA Options	Peru	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.	National policy/ strategy	• Development of a solid waste inventory • Facilitation of the development of a comprehensive national waste management strategy	No

Name	Country	Objective	Action level	Main measures taken	Submitted to the UNFCCC Registry
Disposal and Use of Wastes and Solid and Biomass Residues	Mexico	To promote, through an incentive system, activities of disposal, recycling, reuse and efficient exploitation of the solid wastes at national level, which will result altogether in a better management of the residues.	National policy/strategy	Not specified	Yes
Harnessing Municipal Waste of Big Cities of Pakistan to Generate Electricity	Pakistan	To develop regulatory, legislative and financial instrumental streams for the development and promotion of municipal waste management systems, and deploying them for energy generation.	National policy/strategy	Not specified	Yes
Ordinary Solid Waste NAMA	Costa Rica	Not specified	Technical/operational	• Methane gas capture and destruction in the three major landfills • Valorisation (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	No
Recycling Programme NAMA	Colombia	Support of the Colombian government in transforming the solid waste sector by overcoming various existing policies, financial, market and social barriers. The 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.	National policy/strategy and technical/operational	• Production of fuels from waste, recyclable materials and compost • Potential implementation of landfill gas-to-energy programs on active landfills that currently collect and flare the gas • Separation of organic and recyclable materials • Creation of a NAMA Equity Fund, financed through public resources of Colombia and climate finance contributions from donor countries	No
Rehabilitation of Al-Akaider Landfill	Jordan	Decrease CO_2 and CH_4 emissions from landfills.	Technical/operational	• Implement various technical solutions to decrease emissions	Yes
Revolving Fund for Waste-to-Energy Projects	Philippines	Catalyse private investment in methane capture and utilisation technology in the waste sector through increased regulation, incentives, capacity building and innovative financing.	National policy/strategy and technical/operational	• Develop guidelines for the design, construction and operation of waste-to-energy facilities • Mandate that utilities purchase all power generated from biogas • Capacity building for public-private partnerships to build, operate and maintain WTE facilities	No

Name	Country	Objective	Action level	Main measures taken	Submitted to the UNFCCC Registry
Tourism NAMA in the Dominican Republic	Dominican Republic	To achieve wide-spread adoption of alternative energy technologies and address waste management in the tourism sector.	National policy/ strategy and technical/operational	• Government efforts to streamline the permitting process • A financial mechanism that reduces or eliminates the need for an up-front equity investment • Medium-scale Refuse-Derived Fuel (RDF) and Biomass Densified Fuel (BDF) facilities • Renewable energy solutions that are expected to lower energy costs for the tourism sector • Pilot projects that demonstrate the technical and economic viability of the alternative energy technologies	Yes
Vertically Integrated NAMA for Solid Waste Management	Indonesia	Reduction of emissions from waste and streamline local, provincial and national level policies in the sector.	National policy/ strategy	• Integrating policies on GHG reduction in waste sector at local, provincial and national level • Providing a solid foundation to develop mitigation actions in waste sector • Strengthening horizontal and vertical coordination, as well as institutional aspect • Building stakeholder capacity and awareness • Supporting international networking and cooperation	No

6. Measuring, Reporting and Verifying

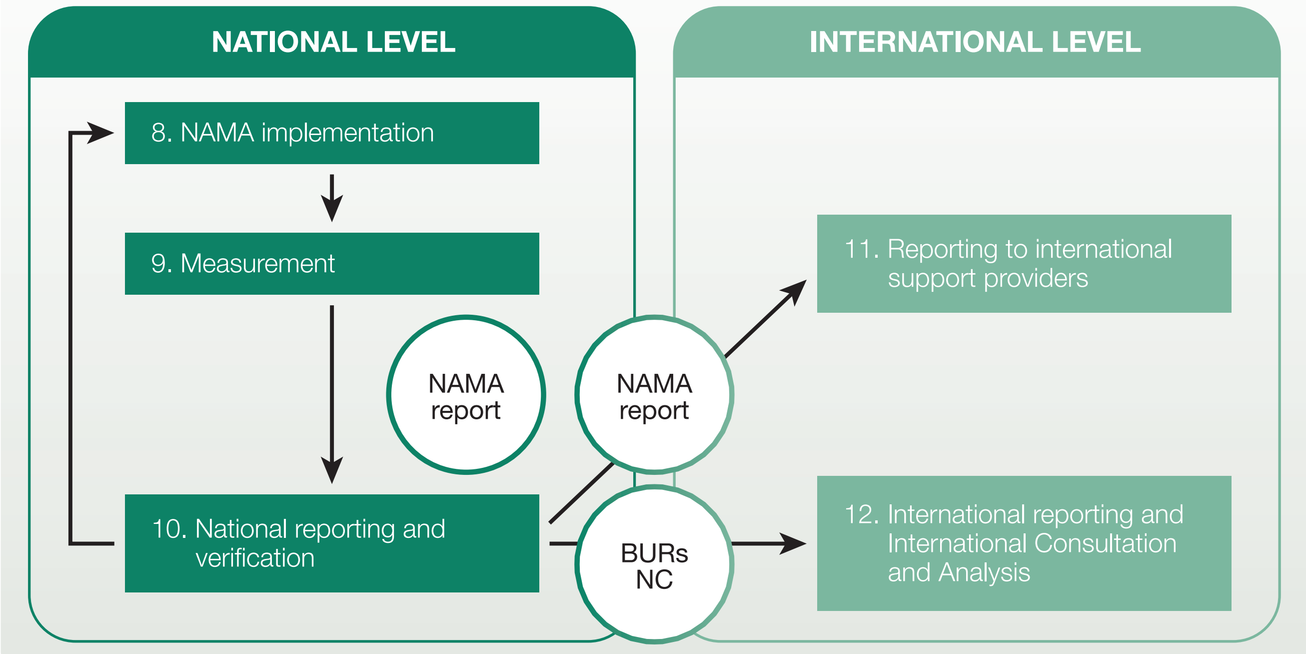
One of the main requirements of NAMAs is measurement, reporting and verification (MRV). The key objective of MRV is to increase the "transparency of mitigation efforts made by the developing countries' as well as build mutual confidence among all countries" (UNFCCC, 2011). Specifically, in the case of supported NAMAs, a well-defined MRV for NAMAs to provide regular verified estimates of GHG emissions impact is crucial to seeking international partners. International partners often require MRV systems to be built with enough soundness, i.e. systems that will track results properly. Countries should consider this when designing an MRV framework. In addition to this, countries should base their MRV approach not only on GHG emissions, but also consider the measurement of other important related impacts and progress indicators, such as sustainable development impacts. Sustainable Development (SD) is also crucial, as international partners, and the countries themselves, do not only seek GHG reduction when developing a NAMA.

The MRV framework includes a well-defined methodology and process for measuring and estimating GHG and sustainable development impacts, a system for reporting and process for verification of claimed impacts. The MRV system is of use to the host country, as well as in tracking the implementation and sustainable development impacts of NAMAs. This chapter provides guidance on measurement methodologies, reporting and verification processes and procedures. It briefly explains the measuring, reporting and verifying framework for NAMAs, and then explains the aspects of developing a measurement methodology for a NAMA on sustainable MSWM.

MRV Framework for Developing Country NAMAs

The MRV requirements for NAMAs will depend on a country's specific need for information and the international requirements for MRV set by the UNFCCC. This section explains in simple terms the complete measuring, reporting and verification framework for developing countries' mitigation actions. In order to understand this framework, it can be divided into two levels: the measuring, reporting and verification of the voluntary national mitigation actions of developing countries under the UNFCCC at the international level, and the measuring, reporting and verifying of the specific individual NAMAs at the national level.

Figure 5. National and International level of MRV for NAMAs
(Sharma and Desgain, 2014)



At the international level, countries have agreed to report on their national mitigation efforts and their national greenhouse gas inventory through National Communications (NC) and Biennial Update Reports (BURs). This includes: measuring parameters to prepare the national greenhouse gas inventory; reporting of information on the national greenhouse gas inventory and the impacts of NAMAs implemented by the country, including on greenhouse gas emissions reductions below BAU; and assessment of the information reported in the BURs through International Consultation and Analysis (ICA), a process where technical experts review the information in consultation with the country concerned, and through a facilitative sharing of views. In addition, supported NAMAs are expected to follow and meet eventual MRV requirements of international partners, donors or investors in NAMAs.

At the national level, the MRV addresses the individual NAMAs. This level supports the international level, and provides the necessary information on NAMAs for countries to feed information into their Biennial Update Reports for the UNFCCC. The information will likely be submitted through a NAMA report to the relevant national authority and eventual international donors, containing the information that the national entity endorsing the NAMA or donor deems relevant and has required the NAMA implementers to measure and report.

The only international requirement set for the national level is based on the general guidelines for domestic measurement, reporting and verification of domestically supported nationally appropriate mitigation actions, recommended by the Conference of the Parties at its 19th session (FCCC/SBSTA/2013/L.28). The guidelines state that: *"Developing country Parties are encouraged to utilize existing domestic processes, arrangements or systems, including domestically available information, methodologies, experts and other aspects, for domestic measurement, reporting and verification. Otherwise, developing country Parties may wish to voluntarily establish domestic processes, arrangements or systems for the domestic measurement, reporting and verification of domestically supported NAMAs."* (UNFCCC, 2013: General Guidelines for domestic measurement, reporting and verification). The guidelines are generic, and allow for significant national interpretation for the development of a domestic MRV system[7].

7 For more information on MRV for NAMAs, in general, see Sharma, 2014: *Nationally Appropriate Mitigation Action: Understanding the MRV framework for developing countries*, UNEP DTU Partnership, http://www.unepdtu.org/PUBLICATIONS/NAMA-Publications

Given the wide range of activities possible under NAMAs, the level of accuracy with which the wide variables of impacts of interest, especially greenhouse gas impacts, can be measured at a given cost is expected to vary significantly. Moreover, the level of accuracy required by financial and other stakeholders may vary. Thus, the approach to measurement and verification could vary from a simple approach to a very accurate and sophisticated one. The MRV system could be simple at the start, but planned for more complex measurements over time.

Finally, it is the country's prerogative, eventually in dialogue with international financiers, to decide how to structure the MRV. The following section represents a suggestion on how an MRV system for MSW could be structured.

Implementing the MRV processes

It is important to note the difference between Monitoring and Measurement. Measurement is measuring data/parameters to monitor the situation. Therefore, measurement is an operational function, while monitoring is a management function. Monitoring is needed to keep track of the progress in implementing the action and its outcome, and take appropriate corrective actions if needed. The institution that oversees the MRV system, i.e. monitors the NAMA, will be responsible for developing and providing guidance on measurement methodology and reporting, and for defining the process for verification. Developers and implementers of NAMAs will be responsible for developing the measurement methodology, collecting the data, and reporting it in accordance with the guidelines.

Monitoring the parameters for assessing MSWMSs requires measuring the same data that is measured for establishing the business as usual scenario or baseline. Some parameters to be monitored and used for estimating GHG emissions may be: waste generation, waste composition, waste collection, waste streams according to waste treatment, gas generation and composition, energy consumption, and energy generation of the project. The frequency of data collection should be determined by the project developers, depending on the activities and capacities available, and under considerations of possible seasonal changes of waste composition and generation, energy consumption, etc.

The GHG emissions of the NAMA scenario could be estimated using computer modelling. The data required for this would need to be collected once (e.g. waste composition) and further parameters may have to be updated more regularly considering seasonal changes, as mentioned before.

Figure 6 provides a good basis for designing a data monitoring system.

Figure 6. Designing a data monitoring system

INDICATORS:	Define key performance indicators

- Input, activity, and outcome
- Indicators should be tailored to the policy or action, based on the type of policy or action, the requirements of stakeholders, the availability of existing data, and the cost of collecting new data

PARAMETERS:	Define parameters for ex-post assessment

- Parameters required to estimate baseline emissions using the emissions estimation method(s) for each source and sink. Parameters are the variables (e.g. actiity data, emission factors) that make up the emissions estimation equations or algorithm

DEFINE TIMELINE:	Define monitoring period for the policy

- The policy monitoring period is the time period over wich the policy or action is monitored
- At the minimum, the policy monitoring period should include the policy implementation period. But note the effects on GHG emissions may go on long after the policy has finished

CREATE:	Create a monitoring plan

- Measurement or data collection, methods, sources of data (either existing or additional data needed), monitoring frequency, whether the data are measured, modelled, calculated or estimated; uncertainties, sampling procedures, documentation, QA/QC

MONITOR:	Monitor parameters over time

- Performance indicators are likely to provide useful information on the validity of the assumptions made in the ex-ante assessment of the policy

Assessment of impacts when designing an MRV system

Assessment of impacts of permanent changes in the waste sector may be difficult to quantify over time, but may rather be established as a quantified impact per year. Such impact estimates should show expected emissions reductions, as well as impacts on other parameters that have been identified as objectives of the NAMA. These could be identified as economic, environmental and social co-benefits:

- **Economic:** The implementation of a sustainable waste national strategy may lead to a reduction of the overall cost of the waste management system, meaning less waste fees for citizens and reduction of costs for municipalities. Additionally, recycling represents an important source of revenue for both the public and private sector, which can benefit from the commercialization of recycled materials. Regional added value, job creation, and the promotion of the participation of the private sector are some of the economic impacts of sustainable MSWMSs.
- **Environmental:** Some of the most significant environmental impacts expected as a result of NAMAs on sustainable MSWMS are the reduction of resource and energy consumption, reduction of GHG emissions and air pollution, elimination of health problems, and avoiding water and soil pollution.
- **Social:** Increase in wellbeing for citizens, due to a better waste service and elimination of social problems for informal waste workers -- social rejection, health problems, bad working conditions, etc. Increase in social awareness and a rise in communal solidarity. A NAMA on sustainable MSWM could also contribute to job creation and economic development by establishing demand for new services, such as waste collection in difficult access areas, recycling, and compost production, among others.

The design of a NAMA MRV system should be based on an assessment of the expected impacts on a qualitative and/or quantitative basis compared to a BAU scenario without the actions envisaged, i.e. the 'baseline' (for example, the number of jobs created or expected, amount of public savings on waste management costs, etc.). Impacts can derive from specific activities or outcomes, as illustrated below in Table 3.

Table 3. Possible impacts associated with sustainable MSWM activities

<table>
<tr><th colspan="7">Outcomes</th></tr>
<tr><td colspan="4">Decreased waste volume diverted to landfills and open dumps</td><td colspan="3">Established separation at source system for municipal solid waste</td></tr>
<tr><th colspan="7">Activities</th></tr>
<tr><td>Offer training programmes</td><td>Create and promote public-private partnerships for building and operation of facilities and its financing</td><td colspan="2">Social awareness programmes for citizens, organising solidarity or cooperation programmes</td><td>Offer environmental awareness raising programmes</td><td colspan="2">Development and implementation of economic enforcement schemes (fees, etc.); or schemes for making citizens take part of the economic revenues of separate waste collection systems

Awareness raising programmes</td></tr>
<tr><td>Climate:
Lower greenhouse gas emissions (compared to business as usual)</td><td>Environment:
Reduction of air, water, and soil pollution</td><td>Social:
Job creation

Know-how transfer</td><td>Economic:
Revenues through commercialization of recycled materials

Creation of added value</td><td>Social:
Creation of new jobs
Increase of income for waste workers/ recyclers

Increased social and environmental awareness of citizens</td><td>Environment:
Reduction of air, water, and soil pollution</td><td>Health:
Reduction of health problems of citizens

Elimination of vector-borne diseases</td></tr>
</table>

One challenge for institutions is the absence or lack of baseline. The overwhelming majority of national institutions involved in NAMA development and implementation are facing the first roadblock in the form of an absence of an adequate data collection system and the lack of necessary data for establishing baselines. Insufficient data hinders a transparent national quantification of the GHG mitigation and sustainability potential. The process of data collection, aggregation and systematization requires significant human capital investment and capacity. The calculation of baselines requires significant data and poses information demands. Data collection, baseline methodology selection and baseline calculations will result in a consequential delay in planning and implementation, which - in the worst-case scenario - may obstruct the NAMA development altogether. It is also a common assumption that the lack of data is a key hurdle stopping investors from getting involved due to insufficient proof of actual energy savings or emissions reductions.

However, while this is a significant problem, it is still possible to overcome. The lack of data should not become a barrier to initiate activities, as the activities themselves generate data over time. Experience shows that NAMA documentation gets revised and baselines adjusted as NAMAs evolve, precisely because the initiation of activities creates data that is used to correct and fine-tune the initial assumptions.

Methodology for measuring, reporting and verifying

Measurement methodologies and procedures

Measurement methodologies and procedures should define how to monitor the expected impacts (including greenhouse gas-related impacts, transformational impacts and sustainable development benefits), the progress (both the status of activities and outputs), and the support given to the NAMA. The measurement methodology includes:

- The geographical scope
- The impact boundaries of the activity on GHG emissions, and the sustainable development benefits
- The baselines for key development benefits and greenhouse gas emissions
- The indicators to measure the impacts
- The data required to measure/estimate the indicators
- A data collection system including clear delegation of data collection responsibilities between the different involved stakeholders
- Establishing procedures to ensure reliability of data collected and estimates

What to measure in a NAMA

To understand what kinds of measurements are required, the guidelines for Biennial Update Reports, as adopted at the 17th session of the Conference of Parties, outline the following types of information that countries are expected to report on NAMAs --planned and implemented-- to the UNFCCC[8]:

- Information on planned NAMAs: progress indicators to track the implementation of the NAMAs, methodologies and assumptions related to estimation of greenhouse gas emissions reduction[9]
- Information on NAMAs under implementation, or implemented: progress of NAMAs under implementation, including the underlying steps taken and further steps envisaged, results achieved, outputs (metrics depending on type of action), and impacts in terms of greenhouse gas emissions reduction

This is the minimum required information that should be measured for NAMAs. The two broad categories of measurement requirements listed are "progress" indicators and "impacts" indicators of NAMAs, including greenhouse gas impacts. Countries are also required to provide the methodology and assumptions made in estimating GHG impacts.

Types of indicators

An indicator is a specific, observable and measurable characteristic that can be used to show progress or measure impacts of a NAMA. There should be at least one indicator for each outcome. The indicator should be focused, clear and specific. The change measured by the indicator should represent progress that the NAMA is expected to bring about in the system. Indicators should be defined precisely to avoid variations in interpretation regarding whether the target has been achieved or not. An indicator should be precise and unambiguous in describing clearly and exactly what is measured. The indicator description should also include clear explanation of the data required. The indicators should aim to be "SMART" (specific, measurable, accurate, realistic and time-bound), while bearing in mind the trade-off between price and precision[10]. The indicators should be chosen to ensure that they are comprehensive, to track the progress and impact of implementation, relevant to the purpose and cost effective.

Indicators can be divided in two categories: progress and impact indicators. Progress indicators track the implementation status of NAMA activities (see Table 4). The expected deliverables for each of the activities described in the national strategy/NAMAs for sustainable MSWM are a good basis for identifying progress indicators, as are the indicators and milestones to measure progress on each of the elements of the implementation plan. Impact indicators refer to the impact of outcomes of NAMAs (see Table 5). These relate to the reduction of greenhouse gas emissions, as well as other objectives served by the activity, in accordance with national sustainable developmental goals.

The measurement methodology must include indicators for all objectives served by the NAMA, including transformational changes that shift the economy towards a low-carbon development pathway. Progress indicators may relate directly to impact indicators if the impact is assessed on the basis of reaching certain milestones. For example, if a NAMA activity is to develop social awareness and cooperation, one of the indicators could be the number of households participating in solidarity programmes with waste workers, or the number of new community-based organisations (see Tables 4 and 5). Both impact and progress indicators help to demonstrate the effectiveness of implementation, and the efficiency of support for specific NAMA activities.

8 Annex III to decision 2/CP.17.

9 It will also include information on the objectives, and a description of NAMAs, including information on the emissions sources covered in the NAMA (sectors and gases) and quantitative goals; steps envisaged to implement the NAMA; barriers, and related financial, technical and capacity needs, including a description of the support needed.

10 In some cases, it may not be possible to have quantitative indicators and, thus, qualitative indicators may be used to measure progress or impacts. In the case of qualitative indicators, the term 'measureable' does not imply measuring exact quantities, but measuring the perceived impacts. For example, social inclusion of waste workers could be a qualitative indicator for perception of citizens or waste workers themselves.

Table 4. Examples of progress indicators

<table>
<tr><th colspan="5">Goal</th></tr>
<tr><td colspan="5">Reducing GHG emissions through sustainable municipal waste management</td></tr>
<tr><th colspan="5">Objectives</th></tr>
<tr><td colspan="2">To decrease by X% the waste volume diverted to landfills and open dumps</td><td colspan="3">To establish a separation at source system for municipal solid waste, with a coverage rate of X%, and a recycling rate of Y%, by (date)</td></tr>
<tr><th colspan="5">Activities</th></tr>
<tr><td>Offer training programmes</td><td>Create and promote public-private partnerships for building and operation of facilities and its financing</td><td>Social awareness programmes for citizens, organising solidarity or cooperation programmes</td><td>Offer environmental awareness raising programmes</td><td>Development and implementation of economic enforcement schemes (fees, etc.); or schemes for making citizens take part of the economic revenues of separate waste collection systems

Awareness raising programmes</td></tr>
<tr><th colspan="5">Progress indicators</th></tr>
<tr><td># of training programmes conducted for local authorities, waste management advisors and other key stakeholders</td><td># of successful PPP with building plans in progress or operating facilities

Tonnes of waste diverted to landfills annually</td><td># of social awareness events for citizens and waste workers

# of newly formed community-based organisations, with inclusion of waste workers</td><td># of environmental awareness raising programmes organised by the municipalities</td><td>Percentage of households participating in the new collection system</td></tr>
</table>

Table 5. Examples of impact indicators

<table>
<tr><th colspan="6">Goal</th></tr>
<tr><td colspan="6">Reducing GHG emissions through sustainable municipal waste management</td></tr>
<tr><th colspan="6">Objectives</th></tr>
<tr><td colspan="4">To decrease by X% the waste volume diverted to landfills and open dumps</td><td colspan="2">To establish a separation at source system for municipal solid waste, with a coverage rate of X%, and a recycling rate of Y%, by (date)</td></tr>
<tr><th colspan="6">Outcomes</th></tr>
<tr><td colspan="4">Decreased waste volume diverted to landfills and open dumps</td><td colspan="2">Established separation at source system for municipal solid waste</td></tr>
<tr><th colspan="6">Impacts</th></tr>
<tr><td>Climate[11]:
• Lower greenhouse gas emissions (compared to business as usual)
• E.g. reduction of fossil fuel consumption, renewable energy generated</td><td>Environment:
• Reduction of air, water, and soil pollution
• E.g. land use avoided, water saved</td><td>Social:
• Job creation (high and low qualified)
• Know-how transfer</td><td>Economic:
• Revenues through commercialization of recycled materials
• Creation of added value</td><td>Social:
• Job creation
• Increase of income for waste workers/ recyclers
• Increased social and environmental awareness of citizens
• Reduction of health problems of citizens
• Elimination of vector-borne diseases</td><td>Environment:
Reduction of air, water, and soil pollution
• Land use avoided
• Water saved</td></tr>
<tr><th colspan="6">Impacts Indicators</th></tr>
<tr><td>tCO_2e reduced</td><td>• Amount of air, water and soil pollutants reduced from reduction of diverted waste to landfills and open dumps</td><td>• Number of new high and low qualified jobs
• Number of international agreements for technical trainings on site</td><td>• Amount of total annual revenues/ total sales within the national recycling market</td><td>• Number of new high and low qualified jobs
• % of income increase for waste workers/ recyclers
• # of newly formed community-based
• organisations, with inclusion of waste workers
• Number of reported gastrointestinal diseases
• Number of reported diseases associated to vectors</td><td>• Amount of air, water and soil pollutants reduced due to avoided use of fossil fuels and extraction of raw materials</td></tr>
</table>

11 Refers only to emissions.

The impact indicators track impacts of outcomes. In this sense, some of the progress indicators could either be used to estimate the impact indicators or the two might use the same data. For example, data for estimating indicators of “tonnes of waste diverted to landfills annually” could also be used for estimating the GHG impacts. The impact indicators also help track the transformational change in the system. For example, the indicator for know-how transfer helps show the knowledge change in the waste sector. The potential benefits identified in the strategy/NAMA for sustainable MSWM are a good starting point for identifying and deciding which indicators are useful to measure, report and verify the impacts of an energy efficient building NAMA on a regular basis. Impacts can be indicated either quantitatively, e.g. tonnes of waste diverted from open dumps, or qualitatively, e.g. perception of citizens regarding waste workers/recyclers after social awareness programmes.

Text box 4. MRV indicators: case study Colombian NAMA on MSWM
(CCAP, 2013)

MRV Indicators for the Colombian waste NAMA

In the case of the NAMA concept for the waste sector in Colombia, the design of the MRV system is already supported by an existing infrastructure for data collection. This is required by private waste operators for collecting landfill waste data for the tariff calculation and payment. This system is administered by the country’s Superintendent for Public Household Services. The new alternative waste treatment facilities envisioned under the NAMA could take the opportunity to use the existing system.

MRV indicators:

- Measuring tonnes of waste diverted from landfills will be the core indicator to calculate GHG reductions. With the total tonnes of waste and periodic composition updates, methane emission reductions can be accurately calculated

Potential secondary MRV indicators to measure sustainable development can be divided into the following:

Environmental

- Rates of recycling both in the formal and informal sectors, measured at the new facilities, at an individual project level and as an overall rate
- Amount of compost and/or Refuse-Derived Fuel produced and coal/fertiliser displaced by their use
- Amount of leachate produced

Economic

- Savings from using Refuse-Derived Fuel, compost, and recyclables in productive processes
- Revenues from sale of Refuse-Derived Fuel, compost, and recyclables
- Reduction in transportation costs of waste to distant landfills
- Extension of landfill life
- Savings for less leachate treatment
- Value of products sold based on recycled materials

Social

- Number of jobs created by the new facilities or other indirect jobs from handling the three commodities produced (recyclables, compost, Refuse-Derived Fuel)
- Number of informal waste pickers hired in the MBT facilities or formalized in other alternative treatment programmes or technologies
- Decreased health effects to population living near landfills or dump sites (to be measured over time as part of the overall NAMA MRV strategy)

Reporting

Reporting entails regular communication from the entity implementing a NAMA to different entities, such as the designated authority that manages the MRV system or the entity providing international support. The parties agree upon the content and format of the reporting templates. Purposes of reporting may include:

- Providing information to the relevant national entity for inclusion in the Biennial Update Report, for the NAMA Registry (which in the case of unilateral NAMAs would be for recognition), for national policy mainstreaming, for impacts on sustainable development and for co-benefits
- Fulfilling requirements per agreement with the entity providing support in accordance with its requirement in a mutually agreed upon protocol, especially regarding GHG emissions reduction impacts
- Tracking the efficiency of the implemented policies and determining how efficient development investments are
- Assisting in legitimizing government's policy implementation

The NAMA should clearly include information on the following aspects: what will be reported, to whom, and the frequency of reporting. A report from the NAMA implementer to the appropriate authorities should include the following information: indicators for assessing progress, the impacts of NAMA implementation, estimation methodology, and assumptions where indicators are estimated from measured data. It should also include a description of the measurement approach and the quality assurance/quality control (QA/QC) procedures used.

Reporting should include all relevant information to enable readers to come to the same conclusions as the report and to replicate the impact results arrived at in the report. In developing reporting formats, it is important to consult with the national authority responsible for coordinating NAMA activities in the country, as well as the entity responsible for preparing BURs. As the primary aim of NAMAs is sustainable development, they should take into account the requirement for national policy makers to assess the sustainable development impacts. In the case of internationally supported NAMAs, they should also take into account the requirements of the entity providing support, especially on greenhouse gas emissions reduction impacts (Sharma, 2014).

Verifying

Verifying confirms that what has been measured and reported --progress in implementation and impacts-- is complete, accurate, and transparently presented, so that a third party would arrive at the same conclusions based on the reported information. What is to be verified --the progress in implementation, GHG emissions reduction impacts, impact of sustainable development benefits, or a combination of these three aspects-- and how the information is verified, will depend partly on the domestic and international entities providing support, and partly on other national reporting requirements, if any.

Verification can be done through documentary evidence or physical evidence. Documentary evidence would consist of verifiers reviewing the reported documents -- this would be the case of the ICA process. Documentary evidence could also be done more in depth by a national entity or entities providing support to evaluate the accuracy of the information, the data quality and the applied quality assurance and quality control procedures. Physical evidence consists of direct observation, usually done through a visit by a verifier to inspect the data where it is measured and stored to assess the soundness of the mode of measuring -- e.g. biodigesters are present, operational and correctly operated, and parameters properly measured.

Verification can be done by different verifiers depending on whether a NAMA is unilateral or if there are other requirements set by a different entity than the NAMA implementer. Domestic verification could consist of first party verification, performed by the same entity responsible for the implementation of the NAMA. Quality control mechanisms should ensure that the verifier is independent of the team or department implementing the NAMA.

A second party could also be in charge of verification, meaning that it should be an entity not included in the NAMA implementation; potentially the entity that sets the standard against which the assessment is done, which could be the national focal point unit for NAMAs. This is similar to the approach used for the evaluation of policies and programmes implemented by governments, where specifically designated governmental departments --ones that are separate from the departments responsible for implementing the programmes or policies-- undertake evaluation to assess the effectiveness of implementation in achieving the objectives of policies and programmes.

Finally, a third party could be responsible for verification, where the implementer is assessed against a standard by an independent organisation that is different from both the implementer and the entity setting the standard. This was the case for the Clean Development Mechanism (CDM) where Designated Operational Entities were the only entities approved for the verification of CDM projects. In the case of internationally supported NAMAs, verification requirements could also be influenced by the international partner supporting the project -- e.g. the Green Climate Fund (GCF) or bilateral donor. For internationally supported NAMAs, third party verification will always be mandatory through the ICA process (Zaballa et al., 2015).

Specific process requirements for MRV support

Developed countries are required to report information on support provided to developing countries through biennial reports and National Communications. Therefore, entities providing financing will require information on utilisation of funds, as well as types of activities supported by their financial contribution, to enable them to meet their reporting obligations to the UNFCCC. This information will be used to assess the provision of climate finance by developed countries, to improve transparency of the support provided and the assessment of global efforts to reach the goal of USD 100 billion of climate change-related funding per year, by 2020. Developing countries are also required to provide information on support received and utilised in the Biennial Update Reports. Such reporting would also highlight the funding received and utilised by recipient countries against the funding provided by developed countries, which may include costs of international administration and international consultants. Thus, entities implementing NAMAs will be required to provide information to the appropriate national authorities to enable host countries to meet their reporting obligations to the UNFCCC.

NAMA financiers, whether national or international, will require effective systems for allocating and tracking financial resources for the implementation of NAMAs, to ensure that funds are used effectively and for the purposes intended. Entities implementing internationally supported NAMAs should adhere to international fiduciary standards. For example, national implementing entities applying for funds from the Adaption Fund must meet the fiduciary standards established by this fund. Similar requirements will emerge for NAMAs. In addition to fiduciary standards, the monitoring of the support provided will also be subject to an agreement between the NAMA host country and the financier for the reporting through the appropriate national authority, ultimately also being subject to verification procedures.

Estimating the impacts of a NAMA for sustainable MSWM and procedures for collecting data

As per the UNFCCC guidelines for the Biennial Update Report (Decision 2/CP.17), both the greenhouse gas emissions and sustainable development impacts need to be assessed and reported. The estimated GHG emissions reduction is the expected amount of carbon dioxide equivalent (tCO_2e) that will be reduced as a direct or indirect result of the activities implemented under the NAMA, to achieve the NAMA objectives. These should be estimated quantitatively and compared to a business as usual scenario. These estimates are based on measured indicators for outcomes of the activities implemented under the NAMA. For example, data for estimating indicators of "tonnes of waste diverted to landfills annually" could also be used for estimating the GHG impacts. For the purpose of transparency and completeness, the direct and indirect greenhouse gas emissions reductions should be distinguished and reported separately.

Direct greenhouse gas emissions reductions are directly attributable to the activities implemented through the NAMAs -- these effects are mediated through an intermediate actor. For example, in a NAMA for sustainable MSWM, the diversion of organic waste from landfills and open dumps reduces methane emissions. Activities that have direct impacts could also have indirect impacts. Indirect greenhouse gas emissions impacts are related to the activities of the NAMA without having a direct causal link. These indirect impacts result from NAMA activities on the behaviour of people who are responsible for making decisions on how to handle waste. For example, the development of a separation at source system for municipal waste leads to an increase in the recycling rate, which has direct impacts on GHG reduction; having an organised and efficient waste collection system could make other people aware of the environmental and health advantages of this system. This could increase the demand of separation at source waste collection systems in the wider population. It may be difficult to quantify the indirect GHG emissions reductions, and in some cases it may need to be expressed qualitatively. Indirect impacts also include impacts beyond the NAMA implementation timeframe. The following activities are likely to have indirect and direct impacts:

- Regulations and their enforcement mechanisms to set waste management practices
- Strengthening capacities for monitoring and enforcing quality of waste services
- Involving commercial banks in providing loans
- Involving the private sector in waste management activities (SMEs, formalized recyclers, etc.)
- Awareness raising activities

The following section provides further details on the calculation of the emissions reductions from sustainable MSWM practices. From the countries' and donor's perspective, conservative approaches are more appealing than overly optimistic assessments. However, in contrast to the Clean Development Mechanism, the NAMA provides a greater degree of flexibility in the calculation of impacts and the use of indicators. This could yield significant variations in the level of accuracy in GHG emissions reduction estimates from the measured outcome of activities, depending on the estimation model employed. In cases where high accuracy could be achievable, but at a high cost, use of conservative estimations, benchmarks, and average factors are likely to be acceptable to the financiers.

- The timeframe for estimating emissions reductions is related to the period over which impacts of implementing the NAMA are realized. The shortest timeframe is the NAMA implementation period, when activities included in the NAMA are implemented. However, in most cases, and in conformity with the objectives of transformational change, impacts will be realized well after the implementation of the NAMA. For example, the impacts of the implementation of separation in source waste collection system with the formalization of the informal recyclers would occur well beyond the programme. Therefore, the choice of timeframe should also reflect the planning horizon of the national initiative.
- It may be beneficial to link the NAMA to internationally discussed timeframes for achieving significant deviation from baseline emissions. The target year of 2020 is often used in negotiations in the Conference of Parties decision for demonstration of deviations from business as usual GHG emissions. It is expected that most of the reductions in greenhouse gas emissions will occur beyond the completion of NAMA activities. Therefore, calculations should state the reductions during and beyond the implementation phase, at least until 2020. For supported NAMAs, the duration of the financial involvement of a third party may set another target date for achievements under the NAMA.

Beyond these strictly emissions reduction related achievements, most NAMAs are expected to accomplish sustainable and transformational development in the targeted sector. To secure long-term transformation, NAMA design should ensure sustainability of impacts beyond the implementation period. A NAMA should strive to achieve a rapid transition to a system where sustainable waste practices, such as waste prevention, recycling appropriate treatment of organic waste, etc., do not have to be supported and become a competitive option. For example, a NAMA could include a requirement to periodically assess the consumer perception of the improved waste services, in terms of financial savings or increased wellbeing, and integrate this assessment with the policy and regulatory framework for supporting the initiative.

Measurement: Calculation of greenhouse gas impacts

The starting point for estimating the GHG emissions of a MSWMS is identifying the key sources of GHG emissions, as well as the factors influencing their generation. The major source of GHG emissions from MSWMS is the degradable organic carbon (DOC), contained in the organic waste. The quantity of GHG emissions is directly proportional to the DOC, which depends greatly on the waste composition and characteristic. In addition, the DOC is strongly affected by the type of waste treatment and final disposal technology. Municipal waste (containing the organic fraction) may be disposed in landfills, incinerated, burned in open sites, recycled, composted or anaerobically treated. Depending on this, the DOC would be modified, and with this the potential GHG emissions.

Recycling activities in MSWMSs may affect the amounts of waste entering into other management and treatment systems. The impact on emissions due to recycling, for example changes in emissions in other industrial production processes where the recycled material is used and transportation, might be calculated depending on the project boundaries -- geography, duration, process boundaries, etc.

For calculating GHG emissions, these factors have to be clearly defined, in order to identify and quantify materials and energy flows and interactions among recycling processes and other different production processes. The reduction may occur in different processing chains, which could include local and international production processes. Emissions reduction also depends on the percentage of raw material substituted, energy mix used in the production process, technology, etc. These variables are beyond the control of the NAMA on sustainable MSWM, making it more difficult to calculate these potential emission reductions as a part of a NAMA. Otherwise, the emissions reduction from recycling may be classified as indirect.

The summarized first step for calculating GHG emissions is to determine data on:
- Waste generation (amounts)
- Waste composition
- Waste management practices (treatment and final disposal)

Figure 7. MSM generation and treatment data - regional defaults
(IPCC, 2006)

Region	MSW Generation Rate[1,2,3] (tonnes/cap/yr)	Fraction of MSW disposed to SWDS	Fraction of MSW incinerated	Fraction of MSW composted	Fraction of other MSW management, unspecified[4]
Asia					
Eastern Asia	0.37	0.55	0.26	0.01	0.18
South-Central Asia	0.21	0.74	-	0.05	0.21
South-East Asia	0.27	0.59	0.09	0.05	0.27
Africa[5]	0.29	0.69	-	-	0.31
Europe					
Eastern Europe	0.38	0.90	0.04	0.01	0.02
Northern Europe	0.64	0.47	0.24	0.08	0.20
Southern Europe	0.52	0.85	0.05	0.05	0.05
Western Europe	0.56	0.47	0.22	0.15	0.15
America					
Caribbean	0.49	0.83	0.02	-	0.15
Central America	0.21	0.50	-	-	0.50
South America	0.26	0.54	0.01	0.003	0.46
North America	0.65	0.58	0.06	0.06	0.29
Oceania[6]	0.69	0.85	-	-	0.15

There are different approaches that could be used for collecting data on waste generation, composition, and waste management practices. For this, both default data and country-specific data can be used. Further information can be found on the methodologies from the IPCC Guidelines for National Greenhouse Gas Inventories (2006, volume 5, chapter 2).

Default data

Region-specific default data on per capita MSW generation, composition, and management practices has been estimated by the IPCC guidelines, based on country-specific data from a limited number of countries in the regions – including specific countries in Eastern Asia and Latin America. In cases where a country does not take into account its own information on waste, these default data could be used for GHG emissions estimation.

Country-specific data

It is considered good practice that countries use their own specific data on waste generation, waste composition and waste practices, when it comes to the calculation of GHG emissions. This information can be found in national waste statistics, municipal surveys, waste management companies, waste associations, international waste organisation, and international databases (IPCC, 2006). Large countries with differences in waste generation, composition, and treatment within the domestic regions are encouraged to be more accurate regarding their data collection, and to consider these local or regional differences.

Data from waste stream analyses

Frequently, MSWM treatment practices are applied in a chain or in parallel, for example, anaerobic digestion after composting or waste separation, recycling, composting, incineration, and, at the end, landfilling. A more accurate but data intensive approach for data collection is to follow the waste flows and their treatment, to determine changes in composition and, therefore, in GHG emissions.

Typically, this kind of accurate waste stream analysis requires high quality country-specific data on waste quantities, treatments and current state of the used technology. This approach is often complemented with modelling. After the modelling, the data calculation should be verified through its comparison with real collected data on MSW generation, treatment and disposal -- especially in cases where they are based largely on modelling. This approach is recommended only when the country has a very high quality of data for verifying the waste stream calculations obtained by modelling. The data needed for this approach could be estimated based on surveys on industry, households and waste management companies/facilities, complemented with statistical data on MSW generation, treatment and disposal (IPCC guidelines, volume 5, and chapter 3).

Estimating GHG emissions

As previously mentioned, the main source of GHG emissions from waste is the organic fraction. The emission potential is influenced by waste composition, degradability and, of course, type of waste treatment applied. Most commonly, MSW in developing countries is disposed of in landfills, unauthorized open dumps, or illegally burned, generating high amounts of GHG.

However, there are other forms of waste treatment that are more in accordance with sustainable waste management, and represent a very interesting GHG reduction potential. These may be composting, anaerobic digestion (AD), controlled and technologically appropriated incineration, and recycling, which, depending on the boundaries of the NAMA project, could represent indirect GHG mitigation potential.

This chapter will briefly describe how to estimate GHG emissions according the waste treatment. GHG can be avoided through diverting organic waste from landfills and treating it with anaerobic digestion, energy recovery or composting. GHG may also be avoided when methane from landfills is collected and flared, or used as an energy source for electricity or heat.

Detailed calculations, sources and figures should be included where possible. Relevant methodologies developed for the Clean Development Mechanism could be employed as these are internationally approved methodologies and are likely to be acceptable to international partners. The Clean Development Mechanism Methodology and associated methodological tools "ACM0022: Alternative waste treatment processes" (https://cdm.unfccc.int/methodologies/DB/YINQ0W7SUYOO2S6GU8E5DYVP2ZC2N3) can be used successfully in project activities related to waste management practices. The CDM methodological tool "emissions from solid waste disposal sites" (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v6.0.0.pdf) can be used for calculating emissions from landfills. For energy recovery, as used as electricity, emissions may be calculated using the CDM methodological "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

The above-mentioned tools provide procedures to calculate baselines, project or leakage emissions, as well as the estimation of total emission reductions of waste management projects. Depending on type of waste treatment or processing chain to be applied, the application of tools and their equations may vary and be combined differently. Examples include: composting before landfilling with or without energy recovery (use of methane as energy source), or AD with energy recovery before composting. Depending on whether the methane is used as energy source or not and on the type of use, the calculation of emissions associated with energy generation should be calculated using the corresponding methodological tool. For estimating emissions from energy generation, the procedure is different for separate electricity generation, only heat generation, or cogeneration. Moreover, the methodology is different if the methane is considered to be treated and used instead of natural gas. For a more comprehensive calculation of baselines and emissions, refer to the noted methodologies.

For example, for electricity generation from landfill gas or biogas (in the case of AD), the emission savings – such as replacing fossil fuel-based electricity-- may be calculated based on the CDM methodological "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". The equations may also be used for calculating potential emission savings when replacing fossil fuel-based energy in the national electricity grid with energy from biogas or landfill gas:

$$PESy = \Sigma Ey * EFeg,y * (1 + TDLy)$$

Where:

$PES_{,y}$ = Project emissions saving in year *y* (tCO_2/yr)
E_y = Quantity of electricity generated by the project in year *y* (MWh/yr)
$EF_{eg,y}$ = Emission factor for national electricity generation in year *y* (tCO_2/MWh)
TDL_y = Average technical transmission and distribution losses for providing electricity (national electricity grid) in year *y*

For example, if landfill gas is collected and used for electricity generation, producing 0.8 MWh/day, the national emission factor for electricity is 0.44, and the TDL is 9% then the PES would be:

PES= 0.8*365*0.44*(1+0.09) = 140 (tCO_2/yr)

The emissions associated with heat generation are calculated if the waste project is providing heat (energy recovery from landfill gas or biogas). The emissions are determined as follows:

$$E_{HG,y} = \frac{HG_{PJ,y} \times EF_{CO2}}{\eta_{HG,BL}}$$

Where:

E_{HG}, = Emission savings associated with heat generation in year y (t CO_2)

η_{HG}, = Efficiency of the boiler or air heater used for heat generation in the baseline

HG_{PJ}, = Quantity of heat supplied by the project activity, displacing heat generation by a fossil fuel j in year y (TJ)

EF_{CO2} = CO_2 emission factor of the fossil fuel type used for heat generation (t CO_2/TJ)

For example, if heat is generated from biogas or landfill gas and is replacing heat currently generated from natural gas (considering replacing heat produced locally in an industrial facility or other facility) the calculation might be as follows (values are assumptions): 80% efficiency for a natural gas-fired boiler, 50.3 tCO_2 per TJ (for natural gas as fuel)

E_{HG}, =5 TJ x 50.3 tCO_2 per TJ / 0.8= 314.4 tCO_2

These are just examples on how to proceed with the estimations of GHG emissions. The mentioned CDM methodological tools would help NAMA developers further to estimate baselines, project related emissions, and emission reductions in a more accurate way. The project emissions and emissions reduction associated with composting or co-composting are calculated according to the methodological tool "Project and leakage emissions from composting". Project emissions from anaerobic digestion are calculated according to the methodological tool "Project and leakage emissions from anaerobic digesters". The methodology ACM0022: Alternative waste treatment processes also describes how to calculate the emissions associated with mechanical or thermal production of Refuse-Derived Fuels, e.g. in cases of waste utilisation for cement plants, and emissions associated with incineration.

Setting the baseline

Setting the baseline for measuring the GHG impacts of the NAMA is the starting point for estimating the GHG impacts of implementing NAMAs. As mentioned earlier, the objective of sustainable MSWM is to include sustainable waste management practices in the waste system elements. The main goal is the reduction of GHG emissions and further environmental problems (air, soil, and water pollution), as well as health and social problems of the waste sector.

The large-scale consolidated CDM methodology for alternative waste management processes (ACM0022) might be used as a guide for setting the baseline for a NAMA on sustainable MSWM. The procedure for setting the baseline is based on the combined tool to identify the baseline scenario. The ACM0022 methodology can be found at https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v5.0.0.pdf.

It was previously mentioned that the first step for calculating GHG emissions of MSWM is to determine data on: waste generation (amounts), waste composition and, waste technologies and practices -- treatment and final disposal. Considering this, it is important to define the appropriate indicators, which would indicate the kind of data to be gathered, and help NAMA developers assess the impact associated with current waste systems and understand the changes over time. The direct indicator for GHG impacts is GHG emissions per unit. However, it is also important to observe the development of waste-related indicators, such as recycling rates, percentage of landfilled waste, and so on. These kinds of indicators may be important for countries, in order to show the effectiveness of waste policies.

NAMA developers may set the baseline, starting by calculating waste generation, waste composition and current waste practices. The quantities of generated waste may be calculated, based on statistics of yearly waste generation per capita (kg waste/person/day), yearly increase of waste generation per capita (% increase/year), and population growth. The waste composition can be estimated based on a sample of waste analysis locally performed and can be used for the estimation of baselines on a regional or national level. In theory, the waste composition should also be modelled according to possible changes due to consumption behaviour changes, industrial development, etc., however, it is very difficult to model and forecast these changes due to their high rate of uncertainty. Nevertheless, for baseline estimations, it is enough to use the current waste composition.

The next step would be the calculation of emissions using, for example, CDM methodological tools and equations according to the type of waste and current waste management practices.

Text box 5. Example of estimations of baseline and scenario: Colombian NAMA on Waste

(CCAP, 2013)

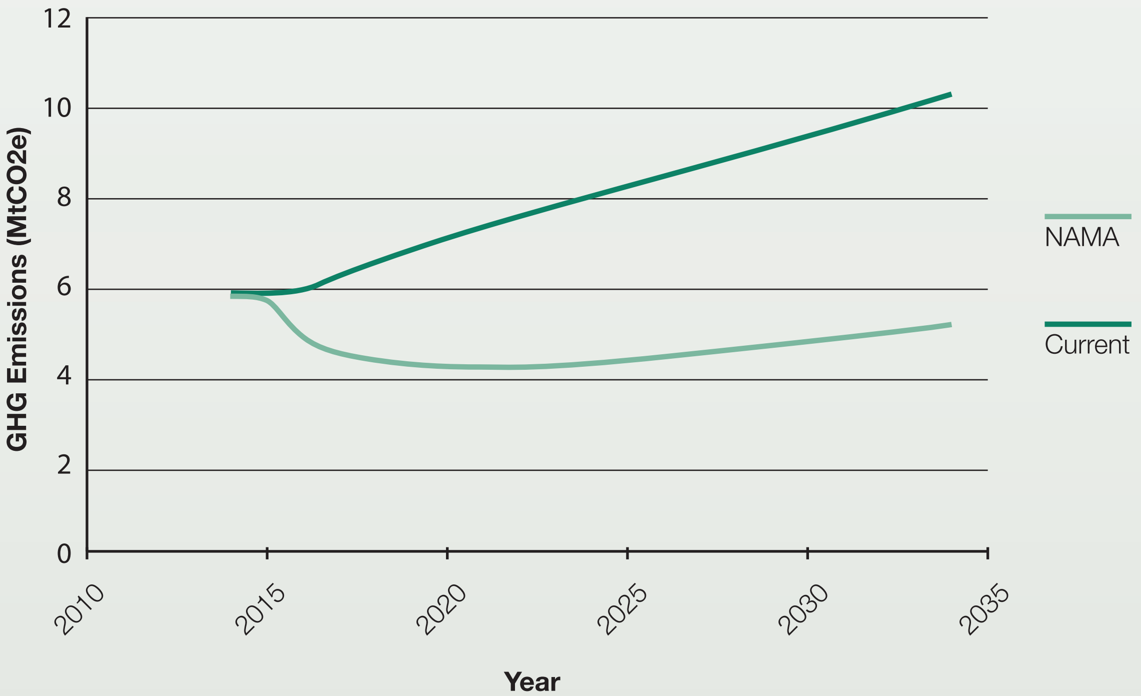
Baselines and NAMA scenarios for the Colombian waste NAMA

According to the last Colombian National Communication, total emissions are 180 million tCO_2e, with the waste sector contributing 5.7%, or 10.3 million tCO_2e. Waste sector emissions are expected to double by 2035 under a BAU scenario, due to an anticipated strong economic and population growth.

The first three planned projects will achieve a 50% landfill diversion rate with an expected emission reduction of 18.2 $MTCO_2e$. Emission reduction estimates have a high potential to double if cities reach a 100% diversion rate. These emission reductions will be achieved through:

- Reduction of biogas emissions from landfills and dump sites (this is 88% of waste sector emissions) – a 50% diversion of waste from landfills will result in a 50% reduction of emissions from landfills (representing 64% of total reduction potential); over time diversion rates are expected to increase as confidence in costs and operation of the technology improves
- Increased recycling – avoiding the production of paper, cardboard, plastics, glass, metals, etc. from raw materials (representing 15% of total reductions)
- Increased use of compost - displacing the use of chemical fertilisers (16% of total reductions)
- Refuse-Derived Fuel use - displacing fossil fuels in cement kilns and other industrial applications (6% of total reductions)
- Decrease in transport of waste from the city to the treatment plants (e.g. the MBT facility could be established much closer to the city than the current location of its municipal landfill), thus reducing GHG emissions due to less transport over a 20 year period
- GHG emission reductions will be immediate and will mostly be methane, a strong Short-Lived Climate Pollutant (SLCP)

Potential improvement in GHG emissions from Landfills



7. Financing a NAMA for sustainable MSWM

Designing and implementing a sustainable financing strategy for a NAMA for sustainable MSWM, including the possible involvement of international financing, is no simple task. NAMA financing cannot be thought of in isolation – it must integrate with current waste policies, institutional structures, stakeholders' roles, and current budgets. The financing aspects of a NAMA are central to its design and should be considered at the earliest stages of the NAMA development. This section provides guidance to the NAMA developer for designing a sustainable long-term finance strategy for MSWMSs that considers the local socioeconomic context. The finance scheme proposed by a NAMA on MSWM should address the main economic challenges of the waste sector, and offer long lasting finance solutions that go beyond the implementation phase of the NAMA. Additionally, it should create the right economic incentives, which can be self-sustainable so stakeholders act, and continue acting, in the way that fulfils the scope of the NAMA.

Four basic sources of funding can be used when implementing NAMAs: public, private, domestic and international. This differentiation becomes important and useful for establishing the order in which sources of financing are to be leveraged. As pointed out by Lütken et al. (2013), the "right order of leveraging" follows the logic that the public sector investment should come first, in order to inspire private-sector investment and attract international donor funding … "the national private sector, however, will rarely have any leveraging power over a foreign public donor, meaning that the national public sector should start its leveraging effort by presenting its policy ideas and potential funding commitments to international donors before it starts deploying its national financing capacity with the aim of securing private sector involvement".

Identifying potential sources of financing for NAMAs on MSWM

A central activity in the design of a NAMA is identifying requirements in terms of financial, technical or capacity building support. Financial support is most relevant for NAMA implementation, so the needs that can be met domestically are specified, while those that would require international support are described quantitatively, to demonstrate how the support will contribute to the activity. The costs of implementing a NAMA on MSWM can be defined as "investment costs", regardless of whether the NAMA is policy or project oriented, As mentioned before, these costs may be covered through grants, donations, public funds, private sector, etc.

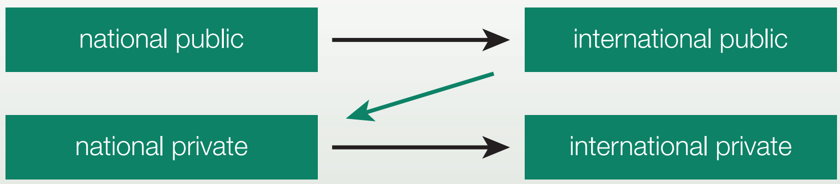
Developing a funding model for a NAMA on MSWM involves exploring and evaluating different sources and kinds of public and private finance. Funding strategies for NAMAs should not solely rely on grants or donations because transformational changes assume a permanent shift in the financing model employed in a sector. Such shifts will be achieved by attracting more sustainable sources of funding, such as private investments, permanent shifts in financing priorities, or bridge financing in anticipation of future savings or changes in market conditions.

Domestic financing

Domestic financing includes budgetary support from public institutions, as well as private sector investment. The following stakeholders may play a key role in mobilising domestic financing for NAMAs on sustainable MSWM:

- Central and local government, such as Ministry of Finance, Ministry of Environment, municipalities

Figure 8. The order of NAMA funding leveraging
(Lütken et al., 2013)



- Private sector: waste management companies (service providers) and/or companies with high energy consumption -- in cases of waste to energy projects
- Banks and other financial service institutions

These stakeholders can contribute to the design and choice of policies, economic instruments, and financial vehicles (loans, grants, rebates or capital investments) that can be used to channel domestic financing toward specific NAMA components. For example, in Mexico, through the National Chamber of Cement (CANACEM), the cement industry signed a National Voluntary Mitigation Action (NAMA) to voluntarily reduce their emissions of CO_2 and achieve a 19% reduction of emissions as an industry for the period 2010 to 2030[12]. This includes the use of waste as Refuse-Derived Fuel (RDF) for co-generation and cement production.

Domestic financing is typically already available given on-going waste activities in countries and, therefore, provides a readily available opportunity to attract additional international funding to expand and improve MSWM services, and in setting framework conditions that make private investment attractive. Often times, capital needs to expand and improve waste services can also be met by domestic financing cost savings through operational efficiency improvements that can be used to leverage private and/or international financing. Depending on the host country's circumstances and abilities, a strong domestic financial contribution will increase the attractiveness of the NAMA for international participation. For example, in 2006 an MSWM project in Dhaka, Bangladesh was launched, aiming at reducing CO_2 emissions through composting of organic waste. This PPP project joined the domestic public sector (Dhaka City Corporation), domestic private sector, and international funding. The total investment of the project amounted to EUR 12 million, which was distributed as follows: 38% as equity, 17% as local loan from a local bank in Bangladesh, and 45% as soft loan from two Dutch banks (UN-HABITAT, 2010). In this case, the revenues come from the sale of compost fertiliser, which is sold to farmers.

Domestic financing may be directed towards 'no regrets' actions that are cost neutral or yield a net profit. The latter would be an obvious target for private sector investment. In addition to revenue generation, other actions that have low investor risks, such as improving operational efficiency and investing own funds, tend to also be more likely to attract private investments.

12 http://www.holcim.com.mx/medios-de-comunicacion/ultima-edicion/latest-release/article/semarnat-and-cespedes-recognize-holcim-mexico-programs-for-reducing-greenhouse-gases-1.html

International funding

International funding for NAMAs has focused on supporting readiness activities, such as institutional capacity building and preparation of concept notes, through either bilateral or multilateral programmes. Most of these programmes have been financed from the 2010 to 2012 'fast start financing' of USD 30 billion, agreed upon at the 15th Conference of Parties. International partnerships have also emerged from these programmes to build knowledge and share views on NAMAs among various institutions[13]. Dedicated initiatives and sources for funding NAMA implementations are emerging, such as the NAMA Facility and the Green Climate Fund.

Some developed countries have announced funding for the implementation of NAMA activities in specific countries. A range of existing bilateral and multilateral funds offers funding to countries for mitigation activities without explicitly targeting NAMAs[14]. Existing programmes offer support opportunities for sector-specific actions, as does the Renewable Energy and Energy Efficiency Partnership. Other development finance institutions continue to provide technical and/or financial support for mitigation measures in various sectors, but without a dedicated 'NAMA financing window'. Nevertheless, MSWM projects may easily find a place under these specific funding programmes, since they often generate positive impacts on different national strategic goals, such as energy efficiency, renewable energy, waste management, low-carbon development, among others.

Similar to domestic finance, international finance is also focused largely on risks and barriers, as well as revenue generation either for profit interests or as additional risk mitigation. However, international finance, in particular donors, tend to also place a strong focus on transformational change and increased impact. Whether resulting from international or own corporate sustainability goals, public and private international finance often seek maximizing GHG reductions for mitigation actions while also positively influencing other impact co-benefits. As such, MSWM projects with ambitious mitigation goals tend to more easily attract international support.

Sustainable financing approaches for NAMAs on MSWM in developing countries

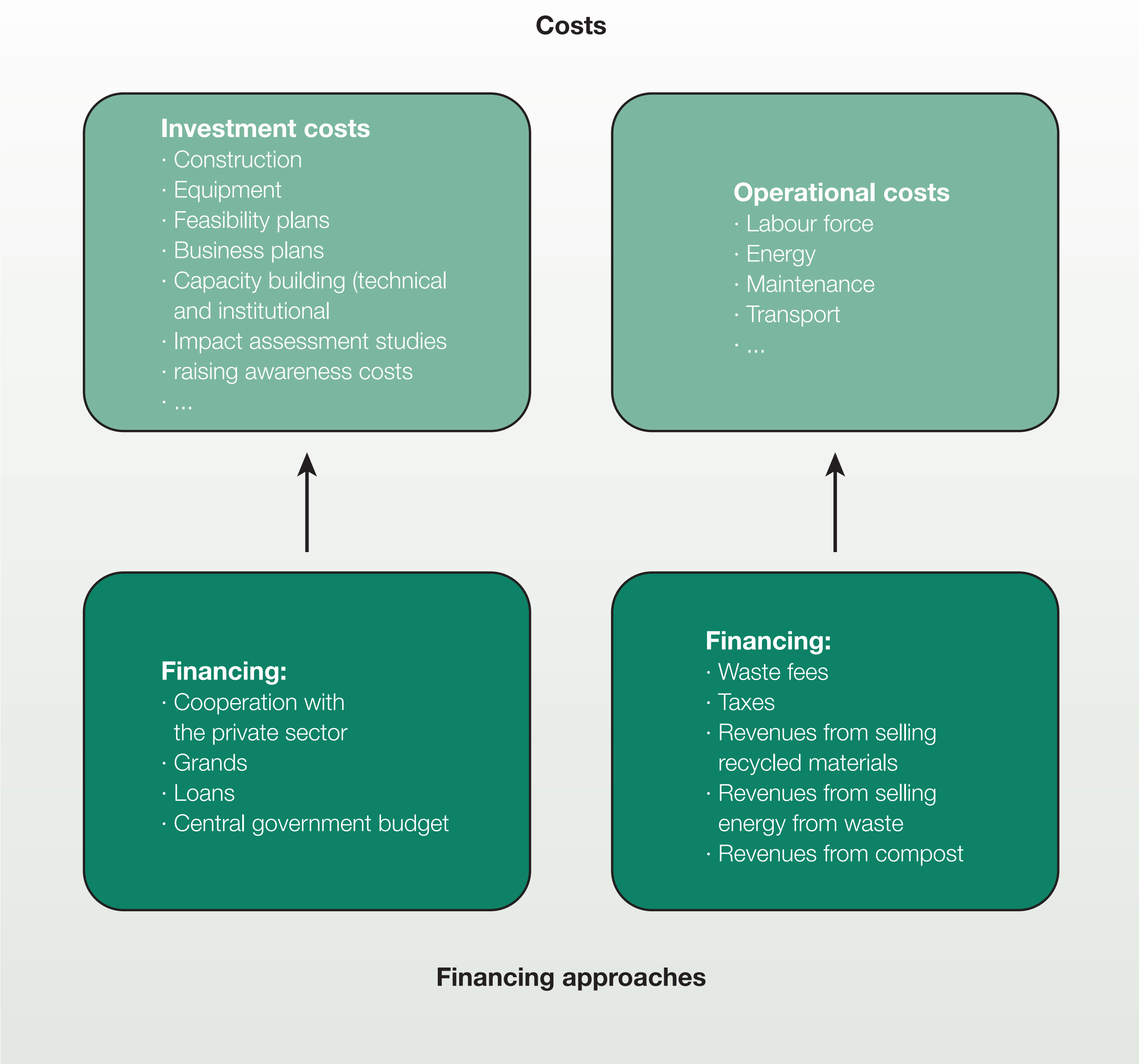
Implementing a NAMA on MSWM may imply high initial investments. Whether the NAMA is carried out at the policy level or the project/operational level, it might

13 For example, the International Partnership on Mitigation and MRV (http://mitigationpartnership.net/) and the NAMA Partnership (http://www.namapartnership.org/).

14 For example, the Global Environment Facility and the International Climate Investment Funds.

require considerable initial investments, including: feasibility studies, business plans, technical consultancy, impact assessment studies, implementation costs, facility construction, land availability, creation of market conditions (e.g. recycling and energy markets), capacity building and raising awareness activities. This can be largely due to the fact that MSWM solutions are not standard and climatic, as well as waste composition factors that may render some technologies more applicable than others for similar projects. Furthermore, after the implementation phase, MSWM projects included in a NAMA will generate operational costs related to their daily activities, such as: labour force, energy, transport, and maintenance, among others. Therefore, MSWM projects should be planned considering sustainable financing and cost recovery measures. Figure 9 shows some examples of costs related to MSWM projects and possible funding mechanisms.

Figure 9. Possible financing options for MSWM projects



Text box 6. Financing NAMAs: Colombian finance strategy for NAMA on Waste

(CCAP, 2013)

Financing the waste NAMA in Colombia

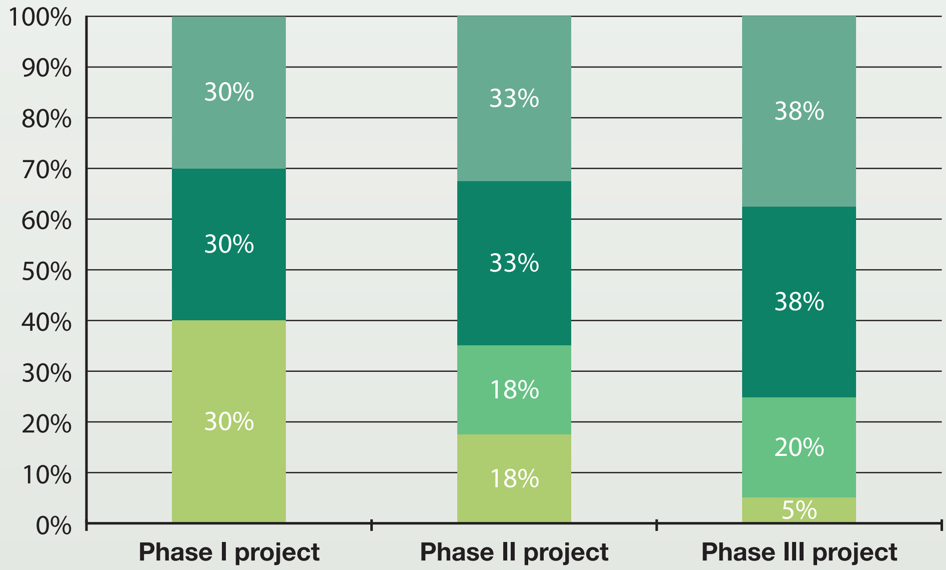
The waste handling tariff in Colombia was designed with a bias toward waste disposal in landfills. As such, private and public operators were more prone to sending their waste to landfills instead of investing in and operating alternative treatment facilities. The waste-handling tariff constitutes 55% of the revenue of landfill sites; thus, a reform of the tariff is central for the NAMA's financial viability. In addition to a tariff reform, additional funding is required to kick-start investments in new waste handling facilities.

A NAMA Equity Fund has been proposed to finance MBT (mechanic biological treatment) facilities to facilitate their financial feasibility and reduce the risk perception of the private sector through demonstration. The Colombian government can provide grants up to 20% of total construction and operating cost of the project. Commercial banks could be willing to lend up to 70% of total project capitalization, and the envisioned Fund for the NAMA will provide equity funds. Although, the Fund will need contributions from both international climate finance donors and the Colombian national and/or subnational governments. It is expected that the Fund would need to be capitalized up to USD 40 million over a three-year period (2014–2016).

The total investment expected is approximately EUR 134 million, a combination of funds from the Equity Fund, contributions from regional environmental authorities, municipalities, utilities, private sector equity capital, commercial debt and concessional debt. It is expected that the private sector will provide both equity and debt financing.

Repayment of equity from project developers will remain in the Fund and will be available for equity investments in future projects. The Fund's equity contribution to the different NAMA phases will decline over time, as the private sector becomes more confident with the MBT technology.

Expected Capital Structure in Three Phases



As mentioned in previous chapters, local governments in developing countries often have limited access to financial resources for MSWM. This problem is exacerbated by low willingness of citizens to pay taxes and waste fees, uncertainty regarding budget definition, and lack of technical capacity in public institutions regarding financial planning and budgetary matters. These factors are preventing municipalities from being more self-financing and are creating operational and financial burdens for local governments.

In order to create sustainable finance schemes for MSWMS, NAMA developers should include key stakeholders from the early stages of the NAMA planning. The strategy considered for a NAMA should be appropriated to the local socioeconomic context and be based on the stakeholders' capacities, as a local resource for developing an autonomous sustainable system. A sustainable finance approach should consider the roles of each stakeholder (formal and informal sectors) and be based on their strengths and synergy.

Funding of operational costs

Currently, municipalities may apply different cost recovery approaches to cover operational costs. They may cover these costs through municipal or property taxes, waste fees, using funds from the central government or a combination of these three. According to PAHO (2010), waste fee collection in Latin America and the Caribbean (LAC) is performed using property tax, electric bill, potable water and sewage bill, and direct bill to the user. Waste fees may be either fixed (equal for all properties in the municipality) or differentiated according to the property type.

However, there are some important issues impacting the effectiveness of these fee collection approaches. These include, the absence of pricing criteria for waste services, low invoice coverage, low willingness of citizens to pay waste service or accept increases of waste fees, and lack of knowledge and out of date information about the real and hidden waste cost streams, and waste quantities (Wilson et al. 2012; Van de Klundert and Lardinois, 1995; PAHO, 2010).

Municipalities using property tax for pricing and collecting waste fees are commonly faced with old cadastral data referring the property value, which does not reflect the real cost of waste collection, treatment and disposal. Therefore, there is no reason for users to reduce the waste generated. Some municipalities calculate waste fees based only on collection and street cleaning services --excluding other activities-- or even calculate waste fees based on old historical data, or distribute the total budget to be covered among citizens. In addition to incorrect calculation criteria for waste fees, municipalities often overestimate the payment capacity of citizens due to the lack of knowledge about their economic situation. This factor, together with the low quality of waste services, contributes to the increase of citizens' reluctance to pay.

To overcome the difficulties mentioned above and cover operational costs in a sustainable way, NAMA on MSWM should be based on financing strategies that link the amount of waste generated with the real costs of waste services -- including collection, treatment, and disposal. The main basis of full recovery of waste management costs is a correct pricing of waste services, instead of depending on donations or external funds. External support may be more effectively used for capacity building in financial planning, feasibility assessments, and management for local governments, or for getting technical support for designing and implementing innovative and appropriated life cycle oriented schemes, such as extended producer responsibility, deposit-refund systems for packages, etc. Table 6 presents some aspects to be considered when establishing waste fees and fee collection approaches.

Table 6. Main considerations for designing pricing and fee collection approaches

Pricing	Fee collection
Detailed cost - benefit analysis, considering also possible benefits and revenues from waste-related activities (user fees, sales revenues from recycled materials, etc.)	Socioeconomic situation (ability to pay) and to which extent the service is used (e.g. companies, hotels, etc.)
Appropriated to the socioeconomic situation (ability to pay) and to which extent the service is used (e.g. companies, hotels, etc.)	Possibility of integration of waste taxes in utility bills (electricity, water, etc.)
Real estimation of waste quantities, waste types, and quantification according to treatment	Willingness to pay and motivation
% waste collection rate and served areas	% waste collection rate and served areas

One possible measure for improving the collection of waste fees may be their inclusion in utility bills. Public service providers have invoicing systems already in place that could be used by municipalities to expand their invoice coverage and ensure fee collection from citizens. In addition, municipalities might reduce their administration costs. The experience of integrating waste fees within other utility bills, such as electricity, has proved to be more effective in collecting service fees than other approaches (PAHO, 2010).

Further options to be considered in a finance scheme for a NAMA on waste would be to involve citizens in performing waste activities within their neighbourhoods. In this case, low-income communities with little or no access to waste services organise themselves, in order to provide these services. Citizens can organise into CBOs (Community Based Organisations) and may be technically or financially supported by NGOs, municipalities or other aid agencies. CBOs can proceed in different ways: participating directly in separation at source activities, waste collection, recycling, and disposal --and profiting from recycled materials-- or sub-contracting waste recyclers associations (formalized private sector) for performing one or more waste services. Through their participation, it is possible for municipalities to reduce waste management costs significantly, especially costs generated in the collection and final disposal phases. CBOs and formalization of recyclers also reduce the institutional burden and administration costs. There are a number of cities that have implemented the CBO-based approach: Mumbai, India, for composting and recycling; Moshi, in Tanzania, where CBOs provide basic collection and sweeping services in the low-income or peri-urban areas; and in Maputo, Mozambique (UN-HABITAT, 2010).

Some potential benefits of adopting this approach are:

- Involving citizens in solving their waste management problems and raising awareness regarding their role in the creation of sustainable waste services
- Increasing social inclusion and creation of communal solidarity
- Creating jobs
- Creating self-sufficient communities
- Know-how transfer to communities through technical support from municipalities, NGOs
- Creating communal added value
- Enhancing mutual cooperation between local authorities and stakeholders of the waste system (community, private formal and informal sector, NGOs, academia, etc.)

A further alternative for funding of operational costs of MSWM would be to assign the management and operation to the private sector. As already explained, companies may be large and highly capitalised or small, for example, CBOs or associated recyclers, contracted for providing primary collection, composting or recycling. Moreover, the typical local and international private sector may also be involved in performing waste services -- waste collection, treatment and disposal. In such cases, the municipality keeps its role of monitoring the system, but further management and operational activities, such as invoicing, fee collection, and planning of routes, are delegated to private waste companies. More information about different mechanisms for private sector participation (operation and investment) is presented below.

Funding of investment costs

Regarding investment costs, local governments may finance them through different sources, depending on their national context, institutional and budgetary arrangements. Municipalities may have access to funds through the central government, grants, donations, and existing financial intermediaries -- such as banks with special lines of credit for waste management facilities. Further possible funding alternatives are franchise, permit, or concession fees, revenues from sale of real estate or equipment, revenues from valorising recyclables or organic waste, and private sector participation (UN-HABITAT, 2010).

In recent years the participation of the private sector has become stronger. The private sector has a high potential to help local government overcome their lack of funds and technical and institutional capacity. A number of cities in developing countries have successful experiences cooperating with the private sector. In these cities, the private sector (big waste companies, SMEs, recyclers' associations, etc.) carries out one or more waste activities, such as primary or secondary collection, waste transport, recycling or final disposal. One of these cities is Dhaka, in Bangladesh, where a composting plant treats 700 tonnes of organic waste per day (see Text box 7). This plant was constructed in 2006 as a result of a PPP agreement between the Dhaka City Corporation and WWR Bio Fertilizer Bangladesh (UN-HABITAT, 2010).

Private sector financing

NAMA projects on MSWM can represent attractive investment opportunities for both domestic and foreign private companies, if they are profitable. The participation of the private sector in waste management services helps to reduce administrative and finance burdens for local governments. The private sector can absorb high investments related to machinery and construction of waste facilities, but in addition to this, private companies often contribute technical and managerial know-how transfer to local governments and further stakeholders. These benefits have been experienced already by a number of cities in developing countries. Therefore, including the private sector (formal and informal) in waste management activities represents an interesting approach towards a sustainable self-finance scheme for NAMAs on MSWM.

Private sector intervention, however, would require a financial structuring that allows a return on the investment. For example, companies with high energy consumption would enter into contracts that allow them to invest in energy recovery from waste, and finance it through the savings on the energy bill coming from replacing their energy source with renewable energy from waste. The private sector only invests if the risk/return ratio is acceptable, therefore, its involvement in the waste management system may require public sector intervention that reduces risks and barriers, or increases returns.

There are four main basic mechanisms to involve the private sector in financing the implementation and/or operation of waste management systems: contracting, concession, franchising, and private subscription or open competition (Cointreau, 1994; Coffey and Coad, 2010). There are a number of cities in developing countries working with the private sector under the modality of contracting. Here, private companies perform only the activities that were previously tendered by the municipality, and contracts are limited to a certain period of time. Private companies are paid for service delivery by the government under the terms of the contract. For instance, Bahir Da, Ethiopia, has implemented contracting as a main mechanism to operate waste management systems. Further examples are: La Paz, Bolivia; Bangkok, Thailand; and Jakarta, Indonesia (Van de Klundert and Lardinois, 1995).

The concession mechanism allows the private sector to build and operate waste facilities --e.g. landfills, recycling plants, composting plants, etc.-- for their own benefit and for a period of time. The most frequently concession mechanisms used in waste management are BOOT (Built, own, operate, transfer), and BOO (built, own, operate). Normally in BOOT partnerships, the facility ownership is transferred to the city for further operation. Here, it is expected that the company recovers its investment from fees charged to users or from selling recyclable materials. In the BOO concession form the private sector does not transfer ownership of facilities to government and it operates the facility, creating a real-world market based on material recovery. Both options allow local government to finance high investment projects, which otherwise would not be possible. Some examples of concessions can be found in Riga, Latvia; Surabaya, Indonesia; Trivandrum, India; Argentina and Brazil; and Dhaka, Bangladesh (UN-HABITAT, 2010; Cointreau, 1994; Gutberlet, 2011).

Some cities prefer to award a franchise (limited time period and zonal area monopoly) to a private company for performing solid waste service. Under this schema, private companies pay a license fee to cover the government's costs of monitoring, and profit through direct charges to the households that are served. The city of Bangkok, Thailand, is an example of a franchise-based recycling (Pumpinyo and Nitivattananon, 2014). In Lusaka, Zambia, community-based organisations (CBOs) contract private waste companies using microfranchising of primary waste collection (UN-HABITAT, 2010).

In some cases, licensed private companies work under an "open competition" scheme, competing with each other to gain and subscribe more individual clients for waste services. For private companies, this scheme means the need for having private arrangements with each household. No firm holds a zonal monopoly, and any number of firms may compete within the same zone. Some cities with this scheme are Nairobi, Kenya, and Kumasi, Ghana (Van Dijki and Oduro-Kwarteng, 2007).

Text box 7. Financing MSWM projects: Example in Dhaka, Bangladesh
(UN-HABITAT, 2010)

Sustainable financing scheme for MSWM at the project level:
Financing Dhaka market composting with public–private partnerships and carbon credits

Situation before the project:
In Dhaka, 3,500 tonnes of waste are generated per day, of which 80% is organic. The Dhaka City Corporation (DCC) can collect only 50% of the waste, and is unable to take care of any increase in waste generation. As a result, uncollected waste is piled up on the roadsides or dumped in open drains and low-lying areas, deteriorating the environment and the quality of life in the city.

Description of the project:
WWR Bio Fertilizer (joint venture company of Waste Concern and World Wide Recycling BV, a Dutch company) has implemented a house-to-house waste collection system and a collection of waste from vegetable markets. Household and market refuse are taken to a community-based composting plant where it is turned into organic fertiliser. The planned total capacity is 700 tonnes/day of organic waste.

The project is anchored on a 15-year concession agreement between Dhaka City Corporation (DCC) and WWR Bio Fertilizer Bangladesh, Ltd. The total investment amounts to EUR 12 million: 38% financed as equity, 45% financed through a soft loan from FMO Bank and Triodos Bank (Dutch Banks), and 17% loan from a local bank in Bangladesh.

Impacts:
- Expansion of the organic fertiliser industry
- Job creation for poor urban residents in waste collection and processing
- Stimulation of behaviour changes in urban communities, a newfound appreciation for the value of waste as a resource
- Reduction of soil pollution and increase of soil fertility, due to the use of synthetic fertilisers and pesticides
- Reduction of greenhouse gases, and inclusion of composting and recycling in the National Safe Water and Sanitation Policy

Text box 8. Financing MSWM projects at the policy/strategic level: Example in Peru
(Communications with MINAM Peru, 2015)

Financing NAMA at the policy/strategic level:
NAMA on solid waste management in Peru

Background:
According to the Peruvian Ministry of Environment, in 2012, 85% of municipal solid waste was being collected in Peru. This, together with waste transport, is a concern for many smaller urban municipalities and rural areas in the country. The end disposal also represents a problem in Peru. There are currently nine landfills operating in the country. These are not sufficient for the 5.8 million tonnes of municipal waste generated annually. For this reason, Peru is planning to achieve 100% adequate treatment of waste via the 3Rs (Reduce, Recycling, Reuse) and sanitary landfills by 2021. This will push the final disposal coverage rate to 42% for non-recoverable waste -- in 2014 over half of the non-recoverable waste was sent to inadequate dump sites. In terms of existing alternative treatment, it is believed that approximately 14% of recyclable waste is actually recycled (via both formal and informal methods), equivalent to a 2.5% recycling rate.

Goal of the NAMA:
To generate a transformational change in the waste sector by minimizing GHG generation from waste management and addressing related environmental, health and social issues, including formalizing the role of informal

recyclers in MSW. In addition, the NAMA should complement and accelerate the existing modernization policy for solid waste management in Peru by creating incentives that increase the economic value of the waste that currently goes to landfills and dumps.

Expected emissions reduction:
It is estimated that this NAMA will achieve the implementation of three technologies (landfill gas capture with electricity generation, landfill gas capture with flaring and source separated organic composting), reducing the country's emissions approximately 8.3 $MTCO_2eq$ cumulative over a period of 15 years, between 2015 and 2030, with a reduction of around 17%, compared to the BAU levels.

Expected Co-benefits of the NAMA:
- **Economic dimension:** Private sector involvement and savings of municipal waste management costs, due to: reduction in transport costs of waste to distant landfills, extended life of costly landfills, cost savings of leachate treatment, added value to recovered materials by creating new products, and private sector and local funds leveraged with NAMA funds
- **Social dimension:** Job creation, decreased health effects to population living near landfills or dumpsites, sustainable livelihoods and better quality of life for vulnerable informal recyclers
- **Environmental dimension:** Matching the country's environmental goals: reduction of leachate generation, avoiding contamination of aquifers, increased recycling that will reduce the use of virgin raw materials (metals, paper, fossil fuels, etc.), and use of compost, partially displacing chemical fertilisers

Stakeholders:
The main stakeholders involved in the NAMA are: the Department of Environmental Quality from the Ministry of Environment, responsible for development and implementation of the national policy in solid waste sector; the Ministry of Economy and Finance (MEF), manages various public funding mechanisms relevant to the NAMA and assesses the yearly governmental budget; and NAMA fund donors.

Finance structure of the NAMA:
The finance structure considers cost sharing between the government of Peru and International Donors, who would contribute equally to the amount of funds needed to make the projects feasible. Furthermore, this NAMA proposes the creation of a Peru NAMA Fund, which will be of a revolving nature where the returns of one project would provide funding for future projects and would provide favourable terms on debt financing to projects.

Forward strategy
The NAMA proposal, including the financial plan, will be a reference document when seeking support, either by approaching potential funders directly and/or making a submission to the NAMA Registry. Potential financing partners should be engaged at an early stage, before the NAMA proposal is drafted, in order to take into account their expectations. It may be helpful to make presentations of the NAMAs at UNFCCC meetings or other events that attract the financial and climate change communities. Additional guidance on how to finance NAMAs can be found in further publications of the UNEP DTU Partnership (http://www.unepdtu.org/PUBLICATIONS).

8. Conclusions

This guidebook describes how to articulate a NAMA on sustainable MSWMSs in developing countries, based on sustainable management and technical approaches, and using the currently available guidance for the structuring of NAMAs. This ensures a systematic approach to NAMA development, which is recognisable and potentially attractive to domestic and international financiers.

Developing countries have several similarities regarding their municipal solid waste management systems (MSWMSs), which are often inefficient and operate at low standards. Inappropriate MSWMS practices have negative impacts on the quality of life; affect the environment, impacting negatively on human health and ecosystems. Methane from landfills, alone, accounts for 12% of total global methane emissions. Incineration is the second most widely used waste disposal practice, generating around 40 $MMTCO_2e$.

The collection rates for domestic waste in developing countries are significantly low (between 43% and 68%), being commonly based on a single disposal option (landfilling or illegal dumping and incineration), representing -despite low performance- high costs for municipalities, which are typically the operators or managers of the waste system. These conditions promote informal waste activities, mainly informal waste collection and recycling. Low performance of the waste services and high waste management costs are aggravated by citizens' lack of willingness to pay formal waste services.

NAMAs can be used for both nationally determined voluntary mitigation actions and specific mitigation actions directed at the sectoral, sub-sectoral or local levels (NAMA on MSWM, in this guideline). The NAMA framework can potentially be a tool for developing countries to create favourable conditions for sustainable development while reducing GHG emissions, tackling current barriers that prevent MSWMSs from transforming to sustainable systems. These barriers may be institutional, policy and legal, economic and finance, social and behavioural, and technical barriers. NAMAs can be used to analyse these barriers and develop appropriate strategies and measures to enable governments to overcome them. For instance, a NAMA on waste may support the implementation of new waste policies, using legal and financial instruments to include formalization of informal recyclers. Integrating the informal recyclers would help countries to reach their Low-Carbon Development and sustainability goals related to the waste sector -- e.g. increase of recycling rates and reduction of GHG emissions, job creation, poverty alleviation, etc.

A sustainable waste management policy developed under the NAMA framework should be based on the 3R waste hierarchy as core principle, and should consider formalization measures, according to the local socio-economic context and stakeholders. Some measures that could be derived from a 3R-based waste policy and included in a NAMA include: clear organisational structures, capacity building, favourable national policies, regulations, political support, law enforcement, waste prevention strategies, formalization of informal recyclers, promotion of community engagement in local waste management systems, restructuring of waste tariff systems, reorganisation of fee collection mechanisms, development of local and national recycling markets, raising public awareness regarding implementation of separation at source system, appropriate local technologies, infrastructure, topography considerations, improved quality of secondary raw materials, among others.

The MRV is an important component of any NAMA. MRV framework includes a well-defined methodology and process for measuring and estimating GHG and sustainable development impacts, system for reporting and process for verification of claimed impacts. A sound MRV system is beneficial to the host country to track the implementation and sustainable development impacts of implementing NAMAs, thereby enabling the assessment of policy effectiveness, the output and justification of the assigned and to legitimize the chosen policies. Given the wide range of activities possible under NAMAs, the level of accuracy of measuring all variables, especially greenhouse gas impacts, can vary significantly. Therefore, the MRV approach could range from being very simple to being a very accurate and sophisticated approach. The MRV system could be simple at the start, but planned for more complex measurements over time. Some examples of possible parameters to be considered in this framework could be: waste generation, waste composition, waste collection, waste streams according to waste treatment, gas generation and composition, energy consumption, and the energy generation of the project (for GHG emissions). The frequency of data collection should be determined by the project developers, depending on the activities, available capacities, and further technical considerations, such as waste composition, seasonal changes, etc.

Another aspect that is essential for the NAMA on sustainable MSWM is the financial aspect. This should be considered at the earliest stages of the NAMA development. Domestic public sector investment should come first, in order to show commitment and inspire international donor funding, and national and international private sector investment. Typically, international funding for NAMAs has focused on supporting readiness activities, such as institutional capacity building and preparation of concept notes, and it cannot be expected that donors will finance the operation of the activities in the long-term. That is why the designing of self-sustainable financing schemes is a key aspect of any NAMA on waste management. This would allow waste activities to continue and be successful. It is important not to depend on external financing sources, but to identify and use current monetary flows. To cover operational costs in a sustainable way, ideally a new cost strategy should link the amount of waste generated with the real costs of waste services -- including collection, treatment, and disposal. The strategy considered for a NAMA should be appropriated to the local socioeconomic context and be based on the stakeholders' capacities, as a local resource for developing an autonomous sustainable system.

Finally, including the private sector (formal and informal) in waste management activities represents an interesting approach towards a sustainable self-finance scheme for NAMAs on MSWM. The private sector may help to reduce administrative and finance burdens of waste management services for local governments. The private sector can absorb high investments related to machinery and construction of waste facilities. Moreover, private companies often contribute with technical and managerial know-how transfer to local governments and further stakeholders. However, in order to engage the private sector in waste management, a financial structuring that allows the return of investments would be required.

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Annex A:

Municipal solid waste management in developing countries: definition, generation and characterisation

Definition

In practice, the definitions of municipal solid waste may vary depending on the country context and jurisdictions. However, there is some consensus on the definitions given by the OECD[15], PAHO[16] and IPCC[17], which define municipal solid waste in a very similar way and include different kinds of waste type, such as: household waste (including hazardous household waste), bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden, street sweepings and municipal services, electronic waste, and market cleansing. Waste from municipal sewage networks and treatment, as well as municipal construction and demolition waste (C&D) are sometimes included in MSW definitions.

This document will consider the MSW definition given by Hoornweg and Bhada-Tata (2012) in their "What a Waste" report for the Wold Bank, which considers all waste types mentioned above, excluding specific hazardous industrial and healthcare wastes.

MSW generation

The generation of municipal solid waste is closely linked to economic and social development, as well as to population growth. According to a World Bank study (Hoornweg and Bhada-Tata, 2012) and USAID (2014), between 1.3 and 1.4 billion tonnes of solid municipal waste are generated globally per year. Due to population growth and increasing waste generation rates, both studies forecast an increase of waste quantities of up to 2.2-2.4 billion tonnes per year by 2025. In the last 10 years, the global municipal waste generation rate per capita (in urban areas) has increased from 0.64 to 1.2 kg/person/day. If this trend continues, the global waste generation rate per capita in urban areas will have been increased to approximately 1.42 kg/person/day by 2025.

Waste generation rates and waste composition are strongly dependent on income, consumption patterns, urbanization rate, industrialization, climate and geographical conditions. In like manner, these factors and their changes are strongly linked to each other. Due to economic development and accelerated industrialization in the cities, urbanization rates in developing countries are also increasing. People from rural areas migrate to urban cities aiming for higher incomes and better living conditions, which also influences consumption patterns of goods and services. Urban residents produce about twice as much waste as their rural counterparts (Hoornweg and Bhada-Tata, 2012). By the year 2050, USAID (2014) forecast a decrease of global rural population of 0.3 billion inhabitants and, at the same time, an increase of 2.6 billion of urban population (compared with the current population).

The following table presents current and projected urban population and waste generation per region (Hoornweg and Bhada-Tata, 2012).

15 Organization for Economic Co-operation and Development
16 Pan American Health Organization
17 International Panel of Climate Change

Current and projected urban population and waste generation per region

(Hoornweg and Bhada-Tata, 2012)

	Current situation			Projections for 2025			% increase
Region	Total urban population (millions)	Waste generation per capita (kg/person/day)	Total (tonnes/day)	Total urban population (millions)	Waste generation per capita (kg/person/day)	Total (tonnes/day)	
Sub-Saharan Africa	260	0.65	169,119	518	0.85	441,840	161
East Asia and the Pacific	777	0.95	738,958	1229	1.5	1,865,379	152
Eastern and Central Asia	227	1.1	254,389	239	1.5	354,810	39
Latin America and the Caribbean	399	1.1	437,545	466	1.6	728,392	66%
Middle East and North Africa	162	1.1	173,545	257	1.43	369,320	113
OECD	729	2.2	1,566,289	842	2.1	1,742,417	11
South Asia	426	0.45	132,410	734	0.77	567,645	329
Total	**2,980**	**1.2**	**3,532,252**	**7,644**	**1.4**	**6,069,703**	**72**

As can be seen from the table, waste generation is increasing at the global level. While Sub-Saharan Africa and South Asia generate about 8.5% of the current global waste, they account for the highest increase percentages by 2025. In contrast to this, OECD countries produce around 44% of the current global waste, but show a rather low increase rate (11%). This phenomenon may have been caused by the strong European waste regulation implemented during the nineties. Waste minimization policies and regulations regarding reduction of waste landfilling might have led several EU member countries to decouple waste generation from economic growth (UNEP, 2010). Nevertheless, this is an exception, and as countries are in a continuous race to meet their development goals, they will achieve higher standards of living, incrementing waste generation rates and total waste production.

MSW composition

As already mentioned, MSW composition is influenced by income, social and consumption patterns, energy consumption, climate and geographical conditions. These factors can also influence the waste composition at the regional or even local level. For example, in countries or cities with cold temperatures in the winter and energy mix for heating based on coal or wood, household waste may contain more ashes or fuel residues than households with heating systems based on electricity or gas. Hoornweg and Bhada-Tata (2012) show an example in China, where part of the population uses coal and the other part uses natural gas for heating. The ash fraction in waste amounts to approximately 47% and 10%, respectively.

The same study compiled information about waste composition by cities and countries worldwide, including data for 105 countries. The tables below present waste composition averages by region and by income level.

Waste composition by region
(Hoornweg and Bhada-Tata , 2012)

Region	Waste materials					
	Organic %	Paper %	Plastic %	Glass %	Metal %	Other %
Sub-Saharan Africa	57	9	13	4	4	13
East Asia and the Pacific	62	10	13	3	2	10
Eastern and Central Asia	47	14	8	7	5	19
Latin America and the Caribbean	54	16	12	4	2	12
Middle East and North Africa	61	14	9	3	3	10
OECD	27	32	11	7	6	17
South Asia	50	4	7	1	1	37

Waste composition by income level
(Hoornweg and Bhada-Tata , 2012)

Income level	Waste materials					
	Organic %	Paper %	Plastic %	Glass %	Metal %	Other %
Low income	64	5	8	3	3	17
Lower middle income	59	9	12	3	2	15
Upper middle income	54	14	11	5	3	13
High income	28	31	11	7	6	17

The countries with low- and middle-income levels generate waste with higher organic waste fractions than high-income countries. In contrast to this, non-organic waste streams (recyclable and non-recyclable) tend to be higher with higher income levels. As mentioned before, industrialization, economic development and changes in lifestyles may cause a transition in consumption trends from non-packaged products to fully over-packaged items. According to Chandrappa and Brown (2012), typical waste characteristics of developing countries are: high waste densities and moisture contents, which are 2-3 times higher than in developed countries, large amounts of organic waste, and large fractions of smaller components (“others”).

Annex B:
Some Existing Programmes for NAMA Readiness Activities

Lead organisations	Initiative	Sources of financial support
UNEP DTU Partnership	ADMIRE – Adaptation & Mitigation Readiness	Danish Energy Agency, Danish International Development Assistance DANIDA
Energy Research Centre of the Netherlands (ECN) and Ecofys	Mitigation Momentum	German Ministry of Environment
Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	International Partnership on Mitigation and Measuring, Reporting and Verifying	German Ministry of Environment
Centre for Clean Air Policy (CCAP)	Mitigation Action Implementation Network	German Ministry of Environment; The Netherlands; and Environment Canada, with additional support from World Bank Institute's Carbon Finance-Assist programme and other donors
Japan International Cooperation Agency (JICA)	Training and Dialogue Programmes on Capacity Development for NAMA/MRV	Ministry of Foreign Affairs, Japan
Global Environment Facility (GEF)	GEF Climate Change Priority	GEF
United Nations Development Programme	Low Emission Capacity Building Programme	Australia; European Commission; and German Ministry of Environment
United Nations Environment Programme	Facilitating Implementation and Readiness for Mitigation	Denmark

a http://www.mitigationmomentum.org/
b http://www.bmu-klimaschutzinitiative.de/en/projects?p=1&d=840
c http://ccap.org/programs/mitigation-action-implementation-network-main/
d http://www.jica.go.jp/english/our_work/types_of_assistance/tech/acceptance/training/about/lineup.htmlhttp://www.jica.go.jp/english/our_work/types_of_ assistance/tech/acceptance/training/about/c8h0vm000066m3ps-att/environmental2013.pdf
e http://lowemissiondevelopment.org/
f http://www.lowcarbondev-support.org/

Annex C:
Some NAMA Funding Organisations

International Climate Initiative (IKI)

- Sponsors/investors: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Germany, and Energy and Climate Fund (EKF)
- Fund size: EUR 120 million (annually)
- Target: Energy (and others) for national/sectoral goal, strategy, national/sectoral policy or programme
- Type of support: Projects, such as developing NAMAs, gaining access to funding for implementation, and implementing ambitious components of NAMAs
- Accessible by: Individual project developers
- Example of project finance: Mitigation Momentum NAMAs
- More information: http://www.international-climate-initiative.com/en/
- Contact: Annual call for proposals: programmbuero@programmbuero-klima.de

The NAMA Facility

- Sponsors/investors: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Germany, and Department of Energy & Climate Change (DECC), UK
- Fund size: EUR 70 million
- Target: NAMA support projects
- Type of support: NAMA support projects (grants)
- Accessible by: Partner governments, individual project developers
- More information and templates: http://www.international-climate-initiative.com/en/issues/nama-facility/
- https://www.gov.uk/government/publications/information-about-the-nationally-appropriate-mitigation-actions-nama-facility
- Contact: contact@NAMA-Facility.org

Global Climate Partnership Fund (GCPF)

- Sponsors/investors: KfW Entwicklungsbank, International Finance Corporation (IFC), Ministry of Foreign Affairs, Denmark, and Deutsche Bank
- Fund size: USD 235 million
- Target: Energy (efficiency and renewables) for emerging and developing countries
- Type of support: Technical, financial (senior and mezzanine debt, limited equity)
- Accessible by: Financial institutions, project developers, sponsors, and technology providers
- More information: http://gcpf.lu/ and http://gcpf.lu/investment-portfolio-62.html
- Contact: info@gcpf.lu

Global Energy Efficiency and Renewable Energy Fund (GEEREF)

- Sponsors/investors: European Union, Germany, Norway, European Investment Bank Group (European Investment Bank and the European Investment Fund)
- Fund size: EUR 112 million
- Target: Energy (efficiency and renewables) for developing countries in Asia, Latin America & Africa
- Type of support: Technical, financial (equity, channels financing to regional funds)
- Accessible by: Regional funds, private equity funds
- More information: http://geeref.com/
- Contact: geeref@eib.org

The Green Climate Fund (anticipated opening in 2014)

- Sponsors/investors: (The World Bank is interim Trustee)
- Fund size: (Anticipated, USD 100 billion)
- Target: Mitigation and adaptation to climate change in developing countries
- More information: http://gcfund.net/home.html
- Contact: Interim Secretariat, isecretariat@gcfund.net

KfW Development & Climate Finance

- Sponsor/investor: KfW, Germany
- Target: Any
- Type of support: Financial (grants, concessional loans, structured financing)
- Accessible by: National governments
- Contact: info@kfw-Entwicklungsbank.de