Assessment methods for waste management decision-support in developing countries

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Assessment methods for waste management decision-support in developing countries

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"Management is doing things right; leadership is doing the right things."
— Peter F. Drucker

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Sintesi

L'importanza di garantire una buona gestione dei rifiuti solidi come un elemento essenziale per lo sviluppo sostenibile è ormai chiara a tutti i livelli: internazionale, nazionale e a livello comunitario. Con la dichiarazione delle Nazioni Unite di Rio del 1992, "Dichiarazione di Rio sull'ambiente e lo sviluppo", e l'Agenda 21 un impegno è stato preso per affrontare la questione e per promuovere una gestione dei rifiuti solidi ecologicamente corretta, socialmente accettabile ed economicamente fattibile. A lottare per migliorare la situazione sono in particolare i gestori dei rifiuti a livello di governo locale nelle aree urbane dei paesi a basso e medio reddito. Servizi esistenti e infrastrutture sono spesso disfunzionali o mancanti. La conseguenza è una minaccia per la salute pubblica e un grave inquinamento ambientale del quale soffre in particolare la popolazione più povera. Trasformare e migliorare la gestione dei rifiuti solidi in una soluzione sostenibile non è un compito semplice. Esso implica l'integrazione e la considerazione di molti aspetti: le questioni tecniche e ingegneristiche, l'impatto ambientale, la sensibilizzazione del pubblico e la sua partecipazione, i fattori socio-culturali, i problemi finanziari ed economici, e le questioni istituzionali, giuridiche e politiche. Per ottenere una visione d'insieme della situazione e per valutare le conseguenze di decisioni e scelte, è necessario un insieme di metodi e strumenti che aiutino a garantire un orientamento strutturato e sistematico e ad ottenere e analizzare dati specifici. Ecco dove i metodi di valutazione per il supporto delle decisioni entrano nel quadro. Essi possono contribuire a: (a) analizzare sia la performance e le cause sottostanti e l'impatto dei progetti e delle attività, e (b) valutare e confrontare le opzioni di miglioramento sulla base dei criteri di scelta.

L'obiettivo di questa tesi è di fornire una serie di strumenti di valutazione e procedure per una migliore pianificazione, progettazione, implementazione e adattamento continuo di progetti relativi ai rifiuti in paesi a basso e medio reddito. In seguito all'analisi dei metodi e degli strumenti per la valutazione attualmente esistenti, così come dei loro vantaggi e svantaggi, è stato sviluppato un questionario semplificato che cattura le principali determinanti di successo per i progetti di sviluppo riguardanti i rifiuti solidi. L'utilizzo di questo strumento è stato validato in 5 casi di studio selezionati in quanto mostrano interessanti elementi innovativi e di successo e considerati come buoni esempi di gestione integrata e sostenibile dei rifiuti solidi nei paesi a basso e medio reddito. I casi sono i seguenti: (1) il compostaggio dei rifiuti a Gianyar, Indonesia, (2) la raccolta dei rifiuti di quartiere a Managua, Nicaragua, (3) una serie di iniziative comunitarie per la raccolta dei rifiuti di quartiere in India, (4) il compostaggio dei rifiuti di mercato a Dhaka, Bangladesh, e (5) la gestione dei rifiuti infettivi a Bangkok, Tailandia.

I risultati mostrano che lo strumento basato sul questionario è adatto a una rapida valutazione di casi esistenti. Dalle informazioni qualitative, strutturate in aree

tematiche, l'utente ottiene facilmente una comprensione dei punti di forza e di debolezza del progetto. In una prima versione dello strumento la capacità di catturare lo sviluppo di un progetto nel tempo era limitata. Di conseguenza sono state aggiunte ulteriori domande aperte a questo proposito. Dato che lo strumento è impostato come un questionario, non è particolarmente adatto a valutare le diverse opzioni di scelta nella fase di pianificazione nel ciclo del progetto. Per questa ragione è proposto uno studio di fattibilità per valutare: (i) il contesto esterno favorevole, (ii) le scelte tecnologiche in base ai principi delle tecnologie appropriate, (iii) l'adeguatezza sociale attraverso l'analisi degli stakeholder e dei social networks, (iv) la fattibilità economica utilizzando metodi di analisi finanziaria, e (v) la valutazione delle emissioni ambientali previste.

I risultati delle analisi dei casi di studio mostrano che alcune caratteristiche comuni dei progetti di successo riguardanti la gestione dei rifiuti solidi sono spesso trascurate durante la pianificazione di nuovi progetti. Queste sono:

- *Struttura organizzativa efficace*: questo comporta un assetto organizzativo per la gestione del progetto con scopi e obiettivi chiaramente definiti, una *leadership* forte e previdente e un personale qualificato e motivato, che segue una formazione professionale continua. L'organizzazione opera secondo i principi di imprenditorialità, di impegno per un servizio di alta qualità, di attenzione al cliente, di responsabilità, trasparenza ed equità.
- *Business model attuabile e finanziariamente ben configurato:* questo comporta un business model e un business plan ben sviluppato, la capacità di sollecitare capitali d'investimento e un meccanismo sostenibile ben concepito per recuperare costi di capitale e costi operativi attraverso fonti di reddito affidabili a lungo termine.
- *Approvazione da parte del governo e conforme alla legge:* questo comporta che il progetto sia riconosciuto come parte integrale della strategia e che sia conforme alle leggi, ai regolamenti, alle norme e ai codici nazionali.

Sulla base dei risultati di questa ricerca due linee guida sono proposte alle organizzazioni di cooperazione o ad altre parti interessate coinvolte in progetti relativi ai rifiuti solidi nei paesi a basso e medio reddito . La prima guida facilita la pianificazione dei progetti, mentre la seconda può essere utilizzata per la valutazione di progetti esistenti.

Executive Summary

The importance of ensuring good solid waste management is now well recognised at all levels: international, national and at community level as one essential element of sustainable development. With the United Nations declaration in Rio in 1992, "Rio Declaration on Environment and Development" and the Agenda 21 a commitment was made to address the issue and to foster environmentally sound, socially acceptable and economically feasible solid waste management. It is especially the waste managers at local government level in urban areas of low- and middle-income countries, who are struggling to improve the situation. Existing services and infrastructure are often dysfunctional or lacking. A large threat to public health and severe environmental pollution is the consequence and it is the poorest of the population that suffer most. Upgrading solid waste management to a long-term sustainable solution is not a simple task. It implies the integration and consideration of many aspects: technical and engineering issues, environmental impacts, public awareness and participation, socio-cultural factors, financial and economic issues as well as institutional, legal and political concerns. To obtain an all-inclusive overview of the situation as well as the possibility to estimate the consequence of decisions and choices, a set of methods and tools is needed, which help ensure a structured and systematic way of thinking and a comprehensive guidance on data collection and analysis. This is where assessment methods for decision support enter into the picture. They can help: (a) to analyze the performance and its underlying causes as well as the impact of projects and activities; and (b) to evaluate and compare between improvement options based on criteria of choice.

The objective of this thesis is to provide support, with a set of assessment tools and procedures, for better planning, design, implementation and continuous adaption of waste projects in low- and middle-income countries. Following the analysis of current existing methods and tools for assessment, with their respective advantages and disadvantages, a simplified questionnaire-based tool was developed which captures the main determinants of success for development projects in solid waste. The use of this tool is validated in 5 case studies, which were selected because they show exciting innovative and successful elements and are considered as good examples of integrated and sustainable solid waste management in low- and middle-income countries. The cases are: (1) waste composting in Gianyar, Indonesia; (2) neighborhood waste collection in Managua, Nicaragua; (3) a selection of community initiatives for neighborhood waste collection in India; (4) market waste composting in Dhaka, Bangladesh; and (5) infectious waste management in Bangkok Thailand.

Results show that the questionnaire-based tool is well suited for a rapid assessment of existing cases. With qualitative information structured in thematic domains, the user obtains easy insight into the strengths and weakness of the project. The first version of the tool had limited capacity in capturing the changes over time. As a consequence, additional open questions were added in this regard to better assess the dynamics of a project. Given that the tool is set up as a questionnaire, it is less suited to evaluate different options of choice in the planning stage of the project cycle. In this regard a feasibility assessment is proposed which evaluates: (i) the enabling environment, (ii)

the technology choices based on the principles of appropriateness, (iii) the social suitability assessed through stakeholder and social network analysis, (iv) the economic feasibility using methods of financial analysis, and (v) the assessment of expected environmental emissions.

Results from case study analysis show that some common key features of successful solid waste management projects are frequently overlooked when planning projects. These are:

- *Effective organizational structure:* This entails having an organizational setup to operate the project; one that is clearly defined in its goals and objectives, has a strong forward looking leadership and skilled, motivated and continuously trained staff. The organization operates under the principles of entrepreneurship, commitment to a high quality of service, customer care, accountability, transparency, and equity.
- *Viable business model and financially sound setup:* This involves ensuring a well-developed business model and business plan, the capacity to mobilize investment capital and well-conceived sustainable mechanisms to recover capital and operational costs through reliable revenue sources over a long-term project period.
- *Endorsement by government and compliance to legislation*: This requires that the project is recognized by the government as an integral part of the overall strategy and is in accordance with national laws, regulations, standards and codes.

Based on the results of this research two guidelines are proposed for development organizations or other stakeholders involved in solid waste projects in low- and middle-income countries. The first assists with the planning of projects while the second can be used for evaluating existing projects.

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List of Abbreviations

ABC	Antecedent-Behavior-Consequence (Behavior Model
AHP	Analytical Hierarchy Process
AIT	Asian Institute of Technology
ALM	Advanced Locality Management (Mumbai, India)
ALMA	Alcadia de Managua (Municipality of Managua)
APMC	Agriculture Produce Market Committee (Delhi, India)
BMA	Bangkok Municipal Authority
CBO	Brazilian Occupation Classification
CAPEX	Capital Expenditures
CBA	Cost-Benefit Analysis
CBO	Community-Based Organization
CDM	Clean Development Mechanism
CEA	Cost-Effectiveness Analysis
CER	Certified Emission Reduction
CI	Consistency Index (in AHP)
COOPAMARE	Cooperativa de Catadores Autônomos de Papel, Aparas e Materiais Reprovitáveis (Brazil)
CR	Consistency Ration (in AHP)
DCC	Dhaka City Corporation
DFID	Department for International Development of the United Kingdom
DSS	Decision Support System
EAP	Engineers Against Poverty
EASEWASTE	Environmental Assessment of Solid Waste Systems and Technologies
EIA	Environmental Impact Assessment
EU	European Union
GDP	Gross National Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GNI	Gross National Income
HIA	Health Impact Assessment
HH	Households
IDR	Indonesian Rupiah
IET	International Emission Trading
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ISSOWAMA	Integrated Sustainable Solid Waste Management in Asia (EU-Project)
ISWM	Integrated Sustainable Waste Management
IWA	International Water Association
IWM	Integrated Waste Management
JI	Joint Implementation
KT	Krugthep Thanakom Ltd. (Bangkok)
LCA	Life Cycle Analysis (Assessment)
LCCA	Life Cycle Cost Approach
LCI	Life Cycle Impact
MCDA	Multi-Criteria Decision Analysis
MCDM	Multi-Criteria Decision Models

MoL	Ministry of Labor (Thailand)
MoNRE	Ministry of Natural Resources and Environment (Thailand)
MoPH	Ministry of Public Health (Thailand)
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGO	Non-governmental Organization
NHSO	National Health Security Office (Thailand)
NIMBY	Not In My Back Yard
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
O&M	Operation and Maintenance
ONA	Organizational Network Analysis
OPEX	Operational Expenditures
OPP	Orangi Pilot Project (Pakistan)
PAHO	Pan-American Health Organization
PCD	Pollution Control Department (Thailand)
PMT	Protection Motivation Theory
PWD	Public Works Department (Dhaka, Bangladesh)
RA	Risk Assessment
RANAS	Risks-Attitudes-Norms-Abilities-Self-regulation (Behaviour Model)
SDC	Swiss Agency for Development and Cooperation
SEA	Strategic Environmental Assessment
SEMANAT	National Ministry of Environment (Mexico)
SFA	Substance Flow Analysis
SLF	Sustainable Livelihood Framework
SLU	Public Cleansing Authority (Brazil)
SME	Small and Medium Enterprises
SNA	Social Network Analysis
SNI	Indonesian National Standards
SSD	Social Security Department (Bangkok, Thailand)
STEEPLED	Social, Technological, Economic, Environmental, Political, Legislative, Ethical and Demographic Analysis
SWM	Solid Waste Management
SWOT	Strengths Weakness Opportunities Threats
TBL	Triple Bottom Line
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environmental Protection Agency
UNFCCC	United Nation Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlements Programme
WB	The World Bank
WIRC	Waste Incineration Research Center (WIRC) at King Monkut's University, (Bangkok, Thailand)
WSP	Water and Sanitation Program
WSSD	World Summit on Sustainable Development

PART 1

1 Introduction

1.1 The Global Waste Challenge

Where people produce and consume goods, they also generate waste.

A brief broad definition of waste is: ‘‘any kind of material, be it solid, liquid or gas, that is discarded and unwanted by its owner’’. Solid waste is material that is not in liquid or gas form. Although, especially often in low- and middle income countries, excreta of humans and animals often ends up in the solid waste stream, the term solid waste generally does not include these materials. Other terms for solid waste are “garbage”, “trash”, “refuse” and “rubbish”. Waste management of a settlement is what is most often labelled as “municipal solid waste management”. When speaking of municipal solid waste, this refers to solid wastes deriving from houses, shops, offices, and hospitals, or lying on streets and in public places. Collecting and managing these wastes are very often the responsibility of municipal or other governmental authorities. Other solid waste generated inside the city, for instance from industrial processes or as a result of construction are typically not considered "municipal waste". Nevertheless they need to be considered as they often also end up in the municipal solid waste stream (Zurbrügg, 2002).

The issue of waste management becomes critical to private and public interest with regard to health and environmental protection when the amounts and types of waste produced exceed the assimilative capacity of the ecosystem. Although small and dispersed communities with ample space and predominately biodegradable waste might bury their waste just outside of their settlements without much harm to personal hygiene, air, soil or water, unfortunately, this is a negligible exception on a global scale. With denser settlement patterns the challenge becomes more acute. Such denser settlement patterns are becoming more frequent and pronounced at a global scale.

Since 2007 more than 50% of the world’s population lives in urban areas. The urban population is estimated to continuously grow, particularly in low- and middle-income countries (Figure 1). Although it is undisputed that urban centers are an inevitable part of development and provide important opportunities for rapid economic growth, providing and maintaining high quality living conditions, with reduced resource use and minimal environmental impact, remains a challenge. The scale of growth in towns and cities offers not only new social and economic opportunities but also more pronounced challenges with regard to urban environmental services. Ensuring the livability of cities is crucial; making them attractive to inhabitants, visitors, businesses, developers and investors. Around the world governments, planners, researchers and

corporations are already looking at ways to make cities more sustainable: using less energy and resources, fostering innovation and stronger communities, and providing populations with livable environments (ISOCARP, 2010).

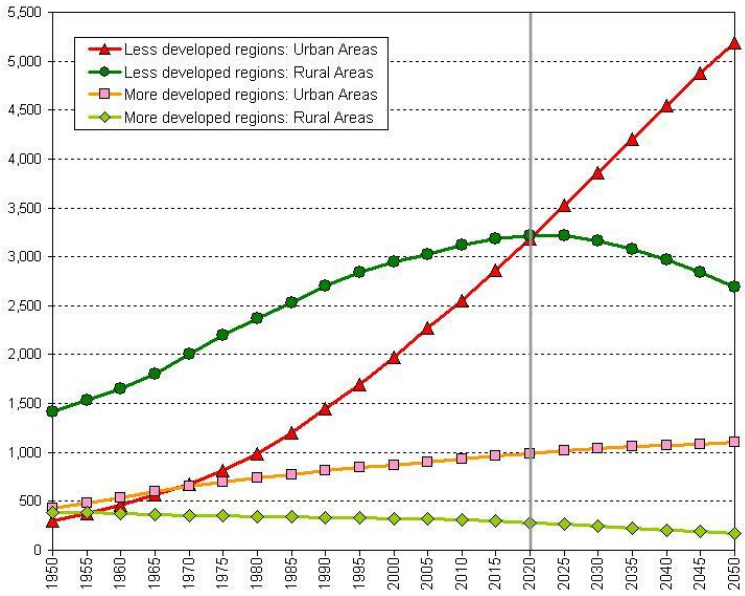


Figure 1 Urban and rural population as percentage of world population (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2007).

Overall waste generation increases with population growth, economic development as well as changes in lifestyle preferences and consumption (Seadon, 2006). As the world develops, waste amounts thus tend to increase and even at global scale this is becoming a major concern.

Among urban environmental services, the management of municipal solid waste (MSW) is one of the major challenges worldwide (Hoornweg and Bhada-Tata, 2012; Sandec / Eawag, 2008). The quantity of municipal solid waste (MSW), an indicator of an urban lifestyle, is growing faster than the urban population. Back in 2002, 2.9 billion urban residents produced around 0.64 kg per capita/day. In 2012 3 billion residents generate 1.2 kg per capita/day and it is estimated that by 2025 this will probably increase to 4.3 billion urban residents producing around 1.42 kg of municipal solid waste per capita/day (Hoornweg and Bhada-Tata, 2012).

However, it is also important to note that large differences exist between the amount and type of waste generated as it depends on the local standard of living, consumption patterns as well as on the level of institutional and commercial activities. Higher economic standing is closely related to an increase in MSW amounts. Cointreau (1983) describes waste generation amounts of 0.4-0.6 kg/capita and day in low-income countries, 0.5-0.9 in middle income countries and 0.7-1.8 in high income countries (Cointreau, 1983). A correlation between gross national income (GNI) and the amount of municipal solid waste produced is also confirmed by further studies as shown in Rouse et al., (2008) as well as shown in an overview of city studies by Sandec / Eawag, (2008) (Figure 2).

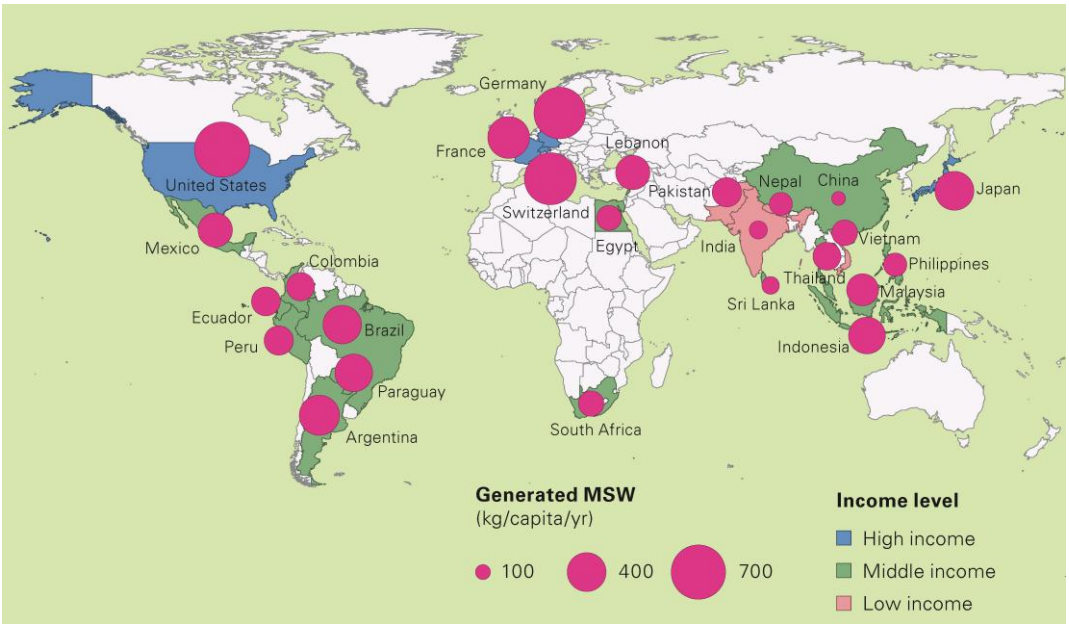


Figure 2 Average municipal solid waste generation (kg/capita/year) in 25 countries grouped according to their Gross National Income (GNI), source (Sandec / Eawag, 2008)

The importance of ensuring good solid waste management is now well recognised at all levels: international, national and at community level. With the United Nations declaration of Rio in 1992, "Rio Declaration on Environment and Development" and the Agenda 21 (UN Department of Social and Economic Affairs, 2012) a commitment was made to address solid waste management issues, which include making it more environmentally sound, socially acceptable and economically feasible, with an emphasis on the increasing service coverage of solid waste services to all urban and rural areas worldwide (Fricke et al., 2007).

Although municipal waste is only one part of the global waste cycle, it is considered challenging given: a) the large amounts (physical quantities), b) the need for public spending and c) social norms. In towns and urban areas there is an urgent need for social rules related to individual hygiene behaviour; rules which consider public interest and which are therefore embedded in social norms. The structure and mechanism of social order and cooperation among individuals within a given human community determines how much waste is generated and how this waste is stored, collected, treated and disposed. Industrial, agricultural or mining waste may be just as or even more hazardous but can be clearly attributed to a few responsible waste producers who can be made accountable for what they generate.

The three main elements of alarm within the topic of waste management can be summarized as: 1) public health: maintaining hygienic and healthy conditions of humans; 2) environmental degradation: local environmental pollution of air, water and soil as well as to issues related to climate change and increasing water scarcity; and 3) resource management: 'closing the loop', i.e. returning both materials and nutrients to beneficial use is crucial to ensure productivity and food security (Scheinberg et al., 2010; Wilson, 2007).

Wilson (2007) describes how in developed countries the drivers for waste management historically developed from resource use to public health and then environmental protection which lasts to date (however underscored by a public awareness and the drive to 'close the loop' and achieve 'sustainable consumption and production'). On the other hand, in developing countries the main driver remains the one of public health. Environmental protection as a driver remains relatively low on the public and political agenda although through international concern on climate change the environmental aspects have obtained more prominence. Waste management has received this renewed environmental importance due to its significance at a global level as an important source of greenhouse gas. Organic waste decomposes in landfills and uncontrolled dumps and produces methane (CH_4). Methane is one of the major greenhouse gases that contribute to climate change. The countries of Asia, Latin America, and Africa together account for about 40 % of the total annual methane emitted from landfills. This is equal to around 37 million metric tons of CO_2 equivalents (EPA, 2012). In developed countries landfill CH_4 emissions have been stabilized due to widespread initiatives of landfill gas capturing. On the other hand, in developing countries with continuing improvements towards controlled (anaerobic) landfilling practices, CH_4 emissions could increase (Bogner et al., 2008). Therefore from a waste perspective, opportunities to reduce greenhouse gas emissions lay in finding better solutions for organic waste treatment, thereby reducing uncontrolled anaerobic decomposition and methane emissions (UN-Habitat, 1996).

In most high income countries the key policy and implementation challenges of waste management relate mainly to how to reduce waste generation and make best possible (re)use of the resources. There is a general consensus on the importance of the "waste management hierarchy" (Figure 3) as a leading strategic concept that defines and underlines the following policy principles in their order of decreasing priority:

- Avoid: All waste that can be avoided makes its further management obsolete.
- Reduce: Waste minimisation conserves resources and reduces costs of all further waste handling steps. With improved environmental management and use of cleaner technology the generation of waste can be reduced, for example by considering subsequent waste treatment already when designing products or by using products which are less environmentally harmful.
- Reuse: This involves multiple use of a product within its original form. This can be for the same or for a new purpose therefore extending the items' life cycle.
- Recycle: These may or may not be similar to the original product. Costs and environmental impact may be associated to the reprocessing steps which need careful evaluation.
- Recover: Extracting energy or material from wastes
- Treat: This may involve reducing volumes before landfilling, or recycling certain waste.
- Dispose: The final option when waste is disposed in a controlled sanitary landfill disposal site.

Implementation of this hierarchy is however, less evident and easy. Solid waste managers, for example, have little influence and control over generation or minimization of waste which is instead in the hands of designers, engineers and managers in industry who decide about what is manufactured, constructed and/or processed. Furthermore, implementing certain activities of avoidance, minimization or reuse may contradict with social or economic feasibility without significantly adding value to the environmental sustainability objectives (Kijak and Moy, 2004). The first three steps of the hierarchy are also strongly dependant on the awareness and behaviour of the population. Here, the main role of waste authorities involves information sharing and educating citizens to enhance awareness and behaviour change in all aspects that relate to solid waste.

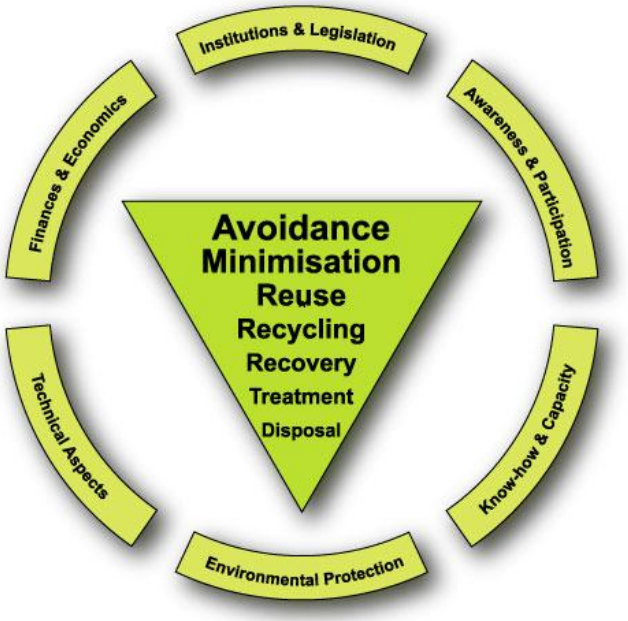


Figure 3 The waste management hierarchy (triangle) where priority of solid waste elements diminish from top to bottom is surrounded by national and local influencing factors (circular boxes).

Nevertheless, the overarching momentum at the international level is building around the goal of resource-use efficiency and the concept of doing more with less. Aspects of 3R (reduce, reuse and recycle) have become a dominant sustainable development policy approach where priorities were set by the World Summit on Sustainable Development (WSSD) in one of its key documents – the '10 Year Framework Programme on Sustainable Consumption and Production' (Barber, 2003). Governments, and civil society together with other stakeholders are hereby encouraged to develop alliances among each other and develop a vision for the future in medium and long term.

1.2 Waste System Elements

A typical municipal solid waste management (MSWM) system can be described by various waste related functional processes and material flow streams.

Waste generation and storage

This refers to the waste producer, who at the same time is the customer of a certain waste management service. The amounts and the characteristics of waste produced will influence and interact with the next element of the waste collection service. Waste generation and composition is largely affected by the factors of income and life style as well as industrialization (UNEP and CalRecovery, 2005). Income affects what is consumed and thus what turns into waste. Furthermore, the way waste is stored at the household and made accessible for collection is critical as it is an interface between service customer and service provider. Storage by the waste producer until the time of collection may be either in-house, on-plot or in the neighborhood (either in open heaps, in bags or in a designated storage container such as a bin or container). Income, but also household hygiene practice, affects how and where waste is contained and this in turn affects composition, i.e. amount of soil, sand, stones in waste, or waste moisture content when left exposed to rainfall (Cointreau, 2006). A wide range of waste producers can be distinguished. Typically in municipal solid waste management the focus lies predominately on the waste from households, commercial facilities, schools and offices (often summarized as institutional waste) and health care centers. However under certain urban conditions, industrial waste and construction debris may also require special attention and in rural areas agricultural waste or mining waste may be also be relevant (Tsuno et al., 2001). In this thesis priority is set on municipal waste, while nevertheless recognizing the relative importance of other waste producers.

Waste collection and transport

This waste system element comprises all tasks and activities related to accessing the waste, collecting it with a certain frequency and moving it to some other location by some kind of vehicle either for further processing or final storage (Pfammatter and Schertenleib, 1996). Accessibility depends on settlement patterns, topography and road infrastructure and the overall system configuration (e.g. vehicles used). Therefore the process of collection and transport can vary considerably from one location to another. In most cities of the developed world, collection is ensured by a fleet of garbage collection trucks which, in predefined regular intervals, collect waste either directly at the household curbside or from designated storage containers where households deposit their waste (Coffey and Sinnatamby, 1988; UNEP and CalRecovery, 2005). In developing countries, typically where road infrastructure and width or topography does not allow access with trucks, a primary waste collection system can be distinguished from secondary collection. Primary collection hereby refers to a first phase of shorter distance collection from households at the curb-side or at a designated point of collection, mostly using smaller vehicles and equipment (Pfammatter and Schertenleib, 1996). The link to the secondary collection, in which larger vehicles transport to more distant locations, is ensured through municipal collection points or transfer stations which are storage locations often emptied in less frequent intervals (Diaz et al., 1996). The transfer stations therefore serve as an intermediary storage unit. A secondary collection system transports waste to either one or more treatment facilities or to a final disposal site. Depending on the system

configuration, collection and transport service may also be specific to certain waste fractions only. Sweeping, to keep public places and roads clear of waste, is also considered one part of waste collection. This is predominantly conducted using manual labor or small mechanical cleansing machinery (Ali and Cotton, 2001).

Treatment processes

This waste system element refers to a controlled engineered process where resources are extracted from waste and waste is converted into another material. Treatment processes have the benefit of reducing environmental threat and producing products from waste or extracting energy value (Cointreau, 1983). Depending on the system configuration, treatment can be specific to certain waste fractions only. Typical examples of waste treatment are: i) composting facilities for organic market, yard or food waste from different sources; ii) biogas facilities for slaughterhouse waste or organic waste from agro-industries; iii) waste incineration for mixed municipal waste or for infectious and toxic healthcare waste (Yang et al., 2009). Scales of the treatment technology can vary significantly, from household small scale to neighborhood medium scale up to city-wide large scale. However, not all ranges of scales are suitable for the various treatment options.

Final disposal

This process describes the activities related to the final storage of waste. Ideally the location is a clearly designated site in which engineering and human control ensure safe storage and minimal health threat and environmental impact (Ali et al., 1999). The waste stored at such locations may be a mix of different materials with or without value depending on the preceding treatment or recycling processes. If recovery and recycling are well established, the waste composition at the final disposal site will consist mainly of fractions which are of limited or no value. Final disposal can also be viewed as a treatment process as parts of the disposed waste will degrade and stabilize over time under aerobic or anaerobic conditions and thus change its material properties. Treatment processes in landfills can also be enhanced with appropriate engineering techniques, e.g. where waste is converted more efficiently or when energy value is exploited (e.g. landfill gas extraction) (Diaz et al., 2005b).

Recycling & Recovery

All activities in the waste management system which have the objective to extract and recover resources and value from waste be this in terms of material or energy, can be summarized as recycling and recovery activities. These may happen in parallel to or jointly with the above mentioned service functions on all levels of the system thereby covering issues of collection, transport, treatment, processing and use (Troschinetz and Mihelcic, 2009). Incentives for recycling, if not driven by a policy commitment or by environmental awareness, are influenced by global markets for that specific resource as well costs and transportation, and commodity prices of products derived from waste (Hoornweg and Bhada-Tata, 2012).

1.3 Waste System Stakeholders

The complexity of solid waste management becomes clear when considering its wide range of stakeholders. A stakeholder is defined as a person, a group of people or an organization that has vested interest in or is concerned about waste management. Stakeholders can affect or be affected by the waste management system elements, its objectives or the related policies and regulations. Not all stakeholders are equal in terms of attitudes, interest, influence, roles, or responsibilities. Any change in the solid waste management system will probably negatively or positively affect each stakeholder. This implies that whatever is done to change and hopefully improve solid waste management must consider the needs and perceptions of all stakeholders and see how they can be taken into account (Alamgir et al., 2012; Bao et al., 2012). Examples for stakeholders in solid waste management and their roles are shown in Table 1. It shows that to a large degree the municipality retains a major role in most activities of solid waste management. In certain elements however, such as treatment, recycling and collection the private sector (formal or informal) plays a significant role and could be integrated more strongly as a key service provider. This shows in the global trend where municipal authorities increasingly contract the private sector for certain waste activities or even attempt to integrate the informal sector into the overall management system (Rouse and Ali, 2008; Furedy, 1986). Formal private sector is typically hired for collection, treatment, or disposal, while the informal sector for recycling.

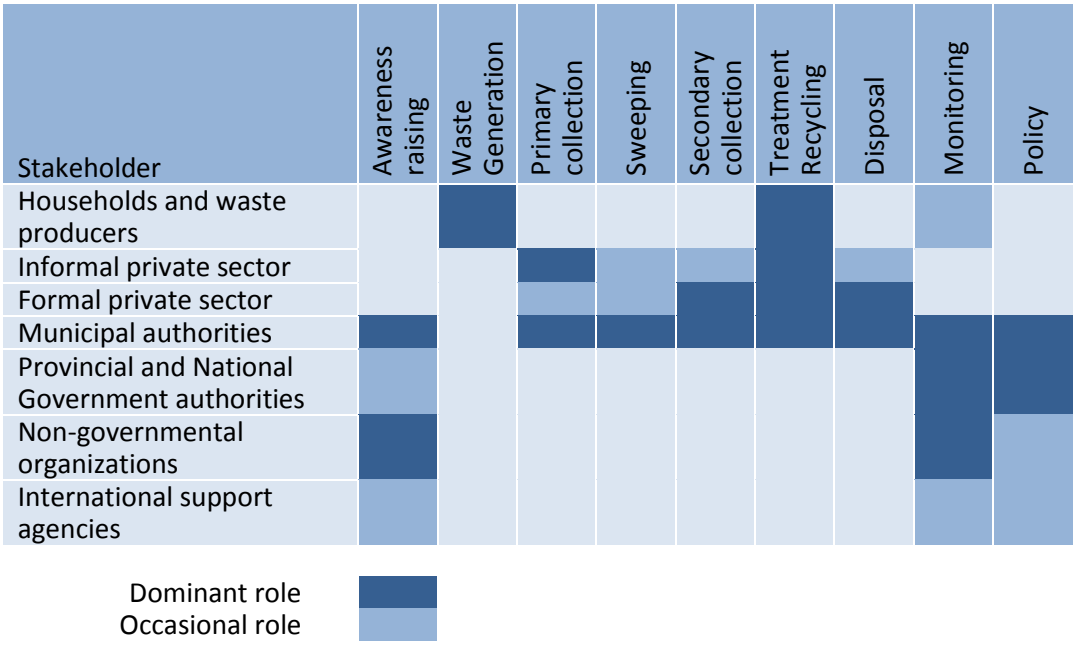
The concept of "Integrated Sustainable Waste Management (ISWM)" (Van de Klundert and Anschütz, 2001) describes how most successes in solid waste management will depend on how stakeholders have been integrated into the process, capitalizing on their strengths to shape a strong team with clearly distributed roles and responsibilities. This encompasses looking at practices, the attitudes and behaviors of the various waste generators, skills of stakeholders involved in the waste management process, work performance and quality of service provided by the municipal staff, or of private enterprises or informal sector (e.g. waste pickers, waste dealers or recyclers) (ISSOWAMA, 2011b). Current state-of-the-art in solid waste management thus involves all stakeholders in a participatory process to foster positive perceptions and attitudes (Bolaane, 2006). In this regard stakeholder methodologies and techniques play a crucial role.

In developing countries it is well known that the informal sector plays a important role in many solid waste management and recycling activities (Ali, 1999; Henry et al., 2006). The informal sector is that group of stakeholders engaged in various livelihood opportunities that are often not recognized and are not perceived as normal income sources on which taxes are paid.

Given the global impact of solid waste management, it is not only local stakeholders that influence and act upon a city's solid waste management system. Increasingly it is also the global community and its international representatives who are pushing local governments to prioritize the "green agenda" of waste management. This green agenda directs priority towards issues of environmental and ecosystem protection and the mitigation of detrimental effects from human activity on the environment at the

regional and global scale. This green agenda however may not necessarily be onj the top list of priorities for local community. They are rather more concerned with the "brown agenda" which has immediate impact on the health risk (McGrahanan and Satterthwaite, 2000). This brown agenda is in fact a representation of the immediate problems at local level that focus and affect direct upon human health and well-being and are those typically suffered most by poor communities. In solid waste management a typical example of this dichotomy is the global pressure to reduce methane emissions and mitigate climate change typically by landfill gas capturing and flaring. At a local level it is however often not landfill management which is ranked first in the list of priorities but rather providing collection services to the poor in urban slums which reflects an immediate and direct health threat for the population.

Table 1 Typical stakeholder roles in the municipal solid waste management system, adapted after Rouse and Ali (2008).



1.4 Private, Public or Merit Good

From an economic point of view solid waste management lies in a complex space between private, public and merit good.

In solid waste management certain services in the system show typical characteristics of a private good, which reflect better "service". Private goods have the main characteristics of: a) Excludability - where customers of goods can be excluded from consuming them if they do not pay for them; b) Rivalry - where the consumption of the good by one customer reduces the amount for other customers to consume; c) Rejectability - where goods and services can be declined should the tastes and preferences of the customer change (Riley, 2012b). Household waste collection - often primary collection by small or medium enterprises - are typical examples of a private service and thus, a private good (Fullerton and Kinnaman, 1996). People pay someone

to regularly collect their household waste either at the curb-side or directly at their homes. Those who do not render payment are not provided service and must find other means to manage their waste. Similarly, collection of recyclable materials at the household level can also be considered a private service. However in many cases the aspect of excludability is not so evident. It is of public interest that the waste collection service also includes the "free-riders" to avoid littering and indiscriminate disposal in and around the neighborhood. With other waste management elements it is even more obvious that these are a type of public good. Street sweeping, secondary collection from community bins and transfer stations or safe disposal at sanitary landfills are not private goods, as those residents who do not pay also benefit from the service of a cleaner environment. Although the service remains rivalrous it is non-excludable, i.e. as those who do not pay benefit from the service. Sustaining a hygienic environment, ensuring public health and protection from environment pollution are the main drivers to ensure that waste management services are provided to all, independent of whether they pay or not. Such aspects are typical of merit goods, where it is judged that an individual or society should have this good on the basis of some concept of need and public interest, rather than the ability and willingness to pay (Riley, 2012a). It can simply be seen as a good that has positive externalities associated with it.

How does this discussion of private, public and merit goods affect the provision of solid waste management? By better understanding the elements and the inherent reasons for service provision, it helps to clarify aspects of responsibility and accountability. For instance if a higher standard of collection services, e.g. a more frequent collection or a household collection instead of community bins are requested by some households, this relates to a private good for which service may be provided by a private entity for a price. However, the overall resulting negative externalities of no or deficient waste management services are the main reasons why local government, i.e. a municipality must retain overall responsibility for the service. Even if certain critical tasks are delegated to the private sector, in light of public interest, the service providers are accountable to local government and control of services is in municipal hands. Also, the far-reaching global impacts of deficient waste management clearly set waste management into the realm of a public or merit good.

1.5 Effects and Impacts of Deficient Waste Management

Lacking waste management affects health, environmental conditions and socio-economic development negatively. This chapter briefly highlights the effects of unsatisfactory urban solid waste management. The causes of deficient waste management services will be described in a later chapter with a special focus on the low and middle-income country situation.

If municipal solid waste remains uncollected, it tends to accumulate in the proximity of residents. This proximity increases the immediate risk of exposure to the negative effects of waste either directly or indirectly by the measures that people take to reduce the accumulation (Bradley et al., 1992). Health and environmental risks from

waste may be caused by many factors which relate to occupational health risks and environmental health risks to residents and workers (Cointreau, 2006; Manga, 2007).

- Exposure to disease transmitting vectors which can proliferate or are in close contact to waste (e.g., flies mosquitos, rodents, dogs, birds, etc.)
- Contact with certain waste types and characteristics (e.g. sharps, infectious or toxic substances)
- Physical risk associated with the handling of the waste without protective measures (e.g., physical injuries, accidents, etc.)
- Exposure to the emissions and risks of waste treatment or disposal (e.g. odour, noise, vibration, accidents, physical stability of dump sites, air and water pollution, explosions, fires, smoke, flooding)
- Exposure to the secondary components generated from waste (e.g. odour, gases, leachates or dust).

1.5.1 Environmental Health Risks

Uncollected waste in settlements often accumulates in open drains, in river gullies, on empty plots, or at the roadsides. During storm events drains are blocked by solid waste. Then, a mix of storm-water, wastewater and waste overflows the drains and floods the neighbourhood creating an unhygienic environment and exposing residents to pathogenic and chemical substances.

Solid waste dumped indiscriminately into empty plots, drains or rivers also offers ideal breeding grounds for disease-transmitting vectors. When rainwater accumulates in waste (such as discarded tires) or when waste blocks drains and channels creating stagnant puddles, these are ideal breeding sites are created for the mosquitos *Aedes aegypti* and *Aedes albopictus* both of which are major vectors of dengue which is basically an urban disease (Dutta and Mahanta, 2006). Furthermore, the malaria transmitting mosquito *Anopheles* was found to breed in similarly polluted, stagnant waters (Awolola et al., 2007). Awolola et al (2007) have shown that *Anopheles gambiae s.s.* is able to adapt to a large range of water quality conditions present in urban areas. This has serious consequences on urban malaria. Biodegradable waste also attracts insects, rodents and other animals that feed on waste; the animals then proliferate and when in contact with humans, transmit disease. In Europe between the 14th and 17th century, the historically most devastating pandemics of plague was caused by fleas carried by ground rodents, and is attributed to roads and neighborhoods covered in garbage and excrements which provided ideal breeding grounds for the rodents. A well-documented case in modern times is from the city of Surat in the state of Gujarat India, where the rapid growth of slums, uncollected waste and indiscriminate dumping led to a proliferation of rats and then, as a consequence to the outbreak of pneumonic plague in September 1994 leaving 56 people dead. This event created global panic and severely affected the city of Surat and the national economy of India. About 60% of the Surat population left the city for fear of falling ill. The industry suffered an estimated loss of about 214 Million USD, although the disease was controlled within a week. Inadequate waste collection and disposal was mentioned most frequently as main cause of the outbreak. Authorities however, argued that it was the non-cooperation and non-compliance of the public and a lack of

awareness about cleanliness that led to the outbreak. This again shows the complexity of providing good solid waste services that are based on an intricate link between stakeholders with different roles and responsibilities (Swamy et al., 2009; van Beukering et al., 1999; Furedy, 1995). Surveys further show that when waste is not collected regularly, the incidence of diarrhoea is twice as high as in areas with frequent waste collection. Also, acute respiratory infections are six times higher in areas with deficient waste collection services (Scheinberg et al., 2010).

Waste in contact with water causes leachate. Chemical substances in waste, usually from household cleaners and industrial solvents, may leach from waste with water in an undiluted or diluted form. If left uncontrolled and untreated, this leachate can pollute groundwater or surface water, creating an environment hazard or threatening health of downstream water users. Similarly, decomposition of organic waste will generate a leachate with high organic loads. If left untreated and then discharged into the environment such leachate may cause severe eutrophication (Cointreau, 2006).

At a global level, greenhouse gas (GHG) emissions from municipal solid waste are considered to contribute up to 5% (1,460 t CO_2e) of annual total global greenhouse gas emissions. Methane released into the atmosphere is a product of anaerobic organic waste decomposition in landfills. It represents approximately 12% of the total global methane emissions (EPA, 2006). For the municipal waste sector, landfills are the source of about half of the methane emitted in 2010 (Bogner et al., 2008). In developing countries disposal is most often uncontrolled and haphazard in open dumps. Often, at the dump site waste is set on fire to reduce waste volume, thus creating a health risk from smoke in the neighbourhood. In the low-income countries of Asia between 80 and 100 % of the waste ends up in open dumps (UNESCAP, 2000). In open dumps, without a concise tipping face, waste is spread out in thinner layers than in an engineered landfill. Thus open dumps tend to emit less methane as compared to sanitary landfills as waste degrades under aerobic conditions (Gyalpo, 2008). The Intergovernmental Panel on Climate Change (IPCC) considers a reduction of methane emissions from shallow (< 5m) open dumps by 60%. (Gyalpo, 2008) Improvements on landfill management in the near future might therefore even increase the generation of landfill methane emissions (Bogner et al., 2008).

1.5.2 Occupational Health Risks

Commonly reported health and injury issues linked to occupational aspects in solid waste management are described in Cointreau (2006). These include: i) injuries as a results of lifting heavy loads, ii) respiratory illness resulting from burning of waste when particulates, bio-aerosols, and volatile organics are generated; iii) injury such as puncture wounds or animal and rodent bites and subsequent infections or, iv) injuries by fires, waste slides or accidents with waste handling equipment. Many occupational health and injury problems can be minimized by better trained staff, simple safety procedures which are systematically followed and protective gear, particularly shoes, gloves and face masks. The dirty nature of solid waste handling also necessitates the provision of water for washing, sanitation, and hygiene facilities to allow workers to maintain personal hygienic conditions (Cointreau, 2006). A study at open dumpsites in

Mumbai, India showed that from 95 solid waste workers surveyed 80% had eye problems, 90% had decreased visual perception, 73% had respiratory ailments, 51% had gastrointestinal ailments, 40% had skin infections or allergies, and 22% had orthopaedic ailments. Clinical examination further showed that 27% had skin lesions, of which 30% were occupation related (Konnoth N. cited in Cointreau, 2006). In Addis Ababa a study shows a clear relationships between workplace exposure and health impacts on waste workers specifically related to open wounds and infections as well as musculoskeletal burdens and fatigue from heavy lifting (Bleck and Wettberg, 2012). The same study also indicates that the exposure of workers may have an even higher impact as they belong to the poor population and are thus subject to overall unfavourable hygienic conditions which also contributes to a basic poor state of worker's health.

1.5.3 Economic Risks

Uncollected waste has an economic cost for a city and for a nation. A visibly unpleasant and dirty city with severe health risks for the population within will make it difficult to attract businesses and/or tourism. Scheinberg et al. (2010) cites three examples of such economic impacts. The first example is from Tangier, Morocco, where beach pollution by solid wastes led to a tourism decline that cost hotels of the area 23 million USD per year in lost revenues. In the second example in Costa Rica, the utility company responsible for the hydro dams started financing plastics recycling schemes in the water shed to mitigate the high costs of turbine failure from plastic waste damage. A last example is taken from a World Bank report where the environment cost of water contamination from improper waste disposal is estimated at 86 million USD annually with the lives of about 40 million Nigerians at risk (Scheinberg et al., 2010). Just as pollution from waste inflicts serious damage on the environment it endangers ecosystem services. Restoring these services (e.g. providing unpolluted, safe drinking water, ensuring fish habitat, clean air, etc.) will come at a cost, and will impact the national economy. The social perception of pollution has shown to result in the devaluation of capital. In the USA landfills - although well managed – impact on property values, which decrease as closer the property is to the disposal site (Thayer et al., 1992). A similar situation, probably even more pronounced, can be expected in low-income countries with open dump locations. However systematic scientific studies are not yet available to confirm this.

1.6 An Overview of Waste Management in Developing Countries

The conditions affecting waste management and the current situation of existing waste management differs greatly between low- and middle-income countries and the high income OECD countries of Europe, North America, or Asia (Fricke et al., 2007). This chapter builds upon the previous chapter which introduced the overall global issues of waste management. It has the objective to highlight these differences based on a literature review and various expert dialogues and open interviews. It further

outlines the current challenges and weaknesses but also opportunities for waste management in developing countries.

A schematic overview of the solid waste management system is shown in Figure 4. Presented are: a) functional waste system technology elements (generation, storage collection treatment, disposal), b) the actor and stakeholders, c) the organizational and management aspects (planning, operation, maintenance, monitoring) and finally d) the external enabling or disabling factors and impact categories. All of this influences the functionality and sustainability of any solid waste management system.

Table 2: Solid waste quantities by Gross National Product country categories; source (Cointreau, 2006).

	Low-income country[++]	Middle-income country[++]	High-income country[++]
Mixed urban waste – large size city[+]	0.50 – 0-75	0.55 – 1.10	0.75 – 2.20
Mixed urban waste – medium size city[+]	0.35 – 0.65	0.45 – 0.75	0.65 – 1.50
Residential waste (kg/cap/day)	0.25 - 0.45	0.35 – 0.65	0.55 – 1.00

[+] Medium city: 100'000 – 500'000 residents; Large city > 500'000 residents.
[++] Country categorization is based on 1992 GNP from 1994 World Development Report published by the World Bank.

At the source of waste generation, low-income countries show a lower average per capita waste amount produced than in high-income countries. Regional and country figures can vary significantly, even within the same city (Hoornweg and Bhada-Tata, 2012). As a global comparison OECD countries generate almost half of the global waste amount while Africa and South Asia are the regions which produce the least waste. Table 2 shows the range for urban solid waste quantities structured by categories of GNP (Cointreau, 2006). The table further shows that average urban per capita waste amounts also depend on the size of the city.

Table 3: Urban s waste characteristics by Gross National Product country categories source (Cointreau, 2006).

Composition and characteristics of raw waste (by wet weight)	Low-income country[++]	Middle-income country[++]	High-income country[++]
Vegetable/Putrescible %	40 - 85	20 - 65	7 - 55
Paper and carton %	1 - 10	12 - 40	15 - 50
Plastic %	1 -11	2 - 13	2 - 20
Metal %	1 - 5	1 - 5	3 - 13
Glass %	1 - 10	1 - 10	4 - 10
Rubber & miscellaneous %	1 - 3	1 - 5	2 - 12
Fines (ash, sand, etc.) %	15 - 50	15 - 40	5- 20
Moisture %	40 - 80	40 – 60	20 - 35
Density in trucks (ky/m3)	250 - 500	170 - 330	120 - 200
Lower heating value (kcal/kg)	800 - 1100	1000 - 1500	1500 - 2700

[++] Country categorization is based on 1992 GNP from 1994 World Development Report published by the World Bank.

Large cities generally generate more waste per capita. Waste generation rates in India from different city sizes show averages of 0.21 kg/cap and day for smaller cities with populations between 100'000-500'000. In comparison in cities > 5’000’000 population average waste generation rates are approximately 0.5 kg/cap and day (Akolkar, 2001). Not only do waste quantities differ between developing and high-income countries, but they also differ in terms of composition (Coffey and Coad, 2010). Table 3 shows differences in waste composition depending on country GNP category (although the range of variation is large).

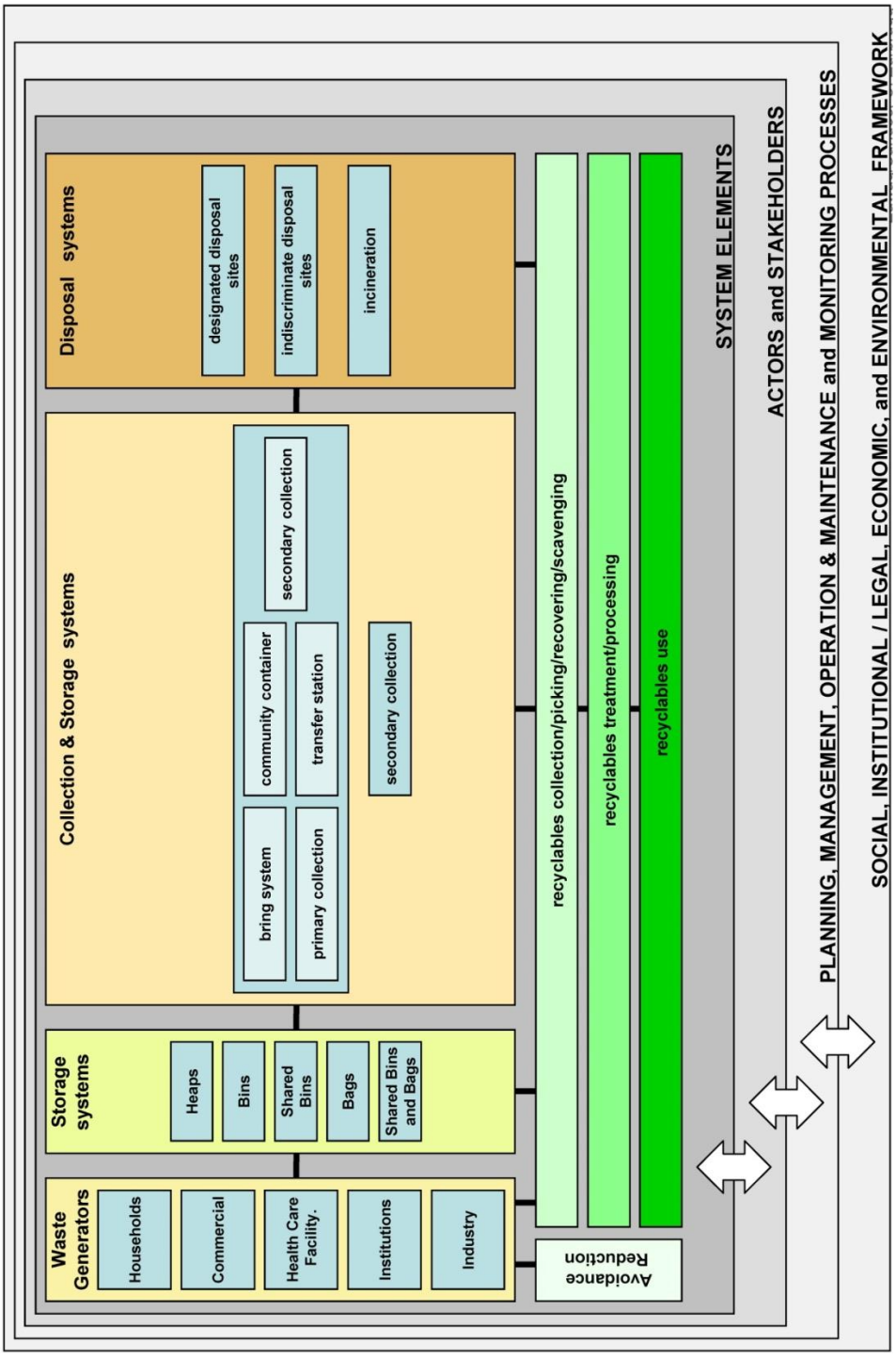


Figure 4 A schematic overview of the solid waste management system.

Generally, the fraction of biodegradable waste is larger in lower income countries and packaging material (paper, cardboard, plastic) is higher in high income countries. This overall tendency is also confirmed by country studies published in Sandec / Eawag, (2008) and Guerrero et al. (in press). Table 4 shows examples of the biodegradable fraction from studies in Asian countries (Zurbrügg, 2002). The high content of organic and putrescible waste and the large amount of inert materials like sand, ash, dust or stones result in high density waste (high weight per volume). This not only affects the selection of appropriate collection vehicles but also it impacts equipment as the abrasiveness of inert material and moisture lead to deterioration of technical parts (Zhu et al., 2008).

Table 4 Average waste characteristics in urban settings, sorted by descending biodegradable waste fraction; source (Zurbrügg, 2002).

	Waste categories (average % by wet weight)						
City (Country)	Putrescible	Paper	Plastic	Glass	Metal	Textiles	Inerts
(Indonesia)	74	10	8	2	2	2	2
Dhaka	70	4.3	4.7	0.3	0.1	4.6	16
Kathmandu	68.1	8.8	11.4	1.6	0.9	3.9	5.3
Bangkok	53	9	19	3	1	7	8
Hanoi	50.1	4.2	5.5		2.5		37.7
Manila	49	19	17		6		9
(India)	42	6	4	2	2	4	40
Karachi	39	10	7	2	1	9	32

The problems of providing equitable and safe service are also exacerbated by rapid demographic changes, unregulated growth of settlements and topographically challenging conditions. The number of slum population in low- and middle-income countries has augmented in 10 years by 61 million (767 million in 2000 and about 828 million in 2010) (UN-Habitat, 2010). Annual slum and urban growth rates are highest in Sub-Saharan Africa with 4.53 % and 4.58 %. Other developing regions show growth rates between 2.2-2.7 % for slum areas and 1.3-2.9 % for urban growth (UN-Habitat, 2006). Much of the waste in slums or low-income neighborhoods is difficult to access, because of road width, slope, congestion, or surface. In the cities it is usually the urban poor that suffer most from poor solid waste management (Kungskulniti, 1990; Lohani, 1984). Municipal authorities are often inclined to allocate their limited capacity and financial resources to service the richer areas of the city which also have higher tax yields and where citizens exert more political power and pressure. Such wealthy residents also have the financial means to avoid some exposure pathways of environmental pollution closest to home. Thus the problems are diverted away from richer neighborhoods to the poorer areas. Considering this, environmental problems at the household or neighborhood level may differ depending on the specific location in the city, although citywide and regional environmental degradation will nevertheless persist or increase.

From a “management and organizational” perspective of solid waste management, differences between low- and middle-income countries and the typical situation in high income countries can be even more unequal. Generally in developing country cities, where “the business” of providing good and safe waste management services is under the responsibility of the local governmental authority (e.g. the municipality),

efficiency and effectiveness are most often not fulfilled. The way the business model is structured and organized hinders efficient and effective waste management services. In a survey among local authorities of Asia cities the following main "internal organizational" obstacles towards improving waste management were reported as (Asia Development Bank Institute, 1998):

- lack of an adequate authority which can address resourcing problems in terms of people and infrastructure,
- fragmentation of responsibilities into a multitude of agencies (local, provincial and national level) all operating within the same municipal boundaries resulting in severe bureaucratic confusion and delays,
- lack of accountability of the authorities or service providers,
- lack of interaction and communication inside the city administration and more importantly between city administration and other stakeholders,
- interference by political interest groups, when elected political representatives become involved in daily operations, instead of focusing on strategic planning, policy setting and monitoring of performance,
- lack of training and available skills within the key staff of the municipal workforce, whereby senior staff may receive training as a reward for good work instead of focusing on where the needs are. Such training is also often considered a chance to break away from the daily obligations instead of seeing this as a step towards increasing responsibilities and accountability.

As an example (Ahmed and Jamwal, 2000) reports on the situation in the Municipal Corporation of Delhi, India where there are about 46,000 workers in solid waste management on the staff list, but only 33,000 are actually available for waste management activities. The absentee rate is high (25%) and many absentees either have other jobs or also serve as domestic servants at the residences of politicians. The sanitary inspector, who supervises them, is aware of the situation but receives compensation to mark the person as present. Strong union laws and inflexible procedures when dealing with government employees make it practically impossible to rectify the situation. Given the high inefficiencies, the budget for solid waste management in developing country cities is often one of the city's highest single budgetary item (Hoornweg and Bhada-Tata, 2012). In Kathmandu, Nepal, in 2004, 25% of total municipal expenditures were for waste collection (Alam et al., 2007). In India practically all the budget dedicated to solid waste management is used for salaries of street sweepers and waste collection (95-100 %) while only very little is spent for treatment and disposal (0-5 %) (Zhu et al., 2008). In comparison, in high income countries less than 10% is used for collection while most expenditures are attributed to treatment facilities (Hoornweg and Bhada-Tata, 2012). Despite the high fraction of expenditures for waste collection and transport, service coverage remains low. In two examples, Sri Lanka and Philippines, data suggests that only 40 % of the waste generated is collected. Other examples from Vietnam and Paraguay show waste collection coverage to be around 50 % or for India around 70 % (Sandec / Eawag, 2008). Table 5 shows typical characteristics of solid waste management in low- middle- and high income countries to highlight and summarize the difference depending on affluence.

Table 5: Typical characteristics of solid waste management, in function of county income, adapted after (Hoornweg and Bhada-Tata, 2012).

Waste management	Low-income countries	Middle-income countries	High-income countries
Collection-Transport	Low coverage rate (< 50%), often irregular and inefficient. Service limited to high visibility and wealthy areas. Often two phases; a) primary collection at neighborhood level with storage at collection point and b) secondary collection from collection point to disposal site.	Improved service and increased regular collection from residential areas. Often larger and better maintained vehicle fleet. Collection coverage between 50 to 80%.	Collection coverage generally greater than 90%. Good roads and accessible neighborhoods allow collection by fleet of larger trucks often highly mechanized and with compaction equipment. Transfer stations are common in large cities.
Recycling	Most often by the informal sector waste recycling at the curbside, neighborhood collection points and disposal site. Recycling rates high depending on market for the materials. Large price fluctuations. Includes a large number of 'middlemen'.	Informal sector still predominant but also organized as cooperatives and recycler groups. Recycling rates are still relatively high. Recycling markets are somewhat more regulated; nevertheless material prices still fluctuate considerably.	Municipality led recycling or by formal enterprises. Public awareness and resident's collaboration generally high. Material collection and processing large scale with mechanized technology. Long-term markets established for products. Recycling rates higher than in low- and middle-income conditions.
Treatment-composting	Becoming more popular. Often small-scale projects, but lacking markets for compost. Eligible for CDM projects but not widespread. Increasing popularity of anaerobic digestion.	Becoming more popular. Often mixed waste composting resulting in low quality compost. Some small-scale projects at the neighborhood level. Eligible for CDM projects but not widespread. Increasing popularity of anaerobic digestion.	Popular at both backyard and large-scale highly mechanized facilities. Source segregation more common. Compost markets often not developed and highly subsidized. Anaerobic digestion increasing in popularity.
Treatment incineration	Neither common nor successful because of high capital, technical complexity, operation costs, high moisture content, and high fraction of inert material.	Some incinerators used, but experiencing financial and operational difficulties. Pollution control equipment often by-passed. Facilities often driven by equipment suppliers and loans/grants/subsidies.	Prevalent in areas with low availability of land. Incinerators have environmental controls and energy recovery system. Governments regulate and monitor emissions.
Landfills / Disposal	Typically open dumps. Polluting to air and water bodies. Waste regularly burned at the dump. Significant health impacts on local residents and workers.	Open dumping still common. Some controlled and sanitary landfills with environmental controls. CDM projects for landfill gas extraction and use are becoming popular.	Sanitary landfills with liners, leak detection, leachate collection and treatment systems, and gas collection. Often for stabilized waste and residues from incineration. Post closure monitoring.
Costs / Revenues	Major budget allocation (70-90%) to collection, transport and street sweeping. Revenues from taxes.	Allocation to collection between 50-80%. Revenues from tariffs and taxes.	Large budget allocation to treatment facilities. Allocation to collection low (<10%). Revenues increasingly by pay-as-you-throw systems.
Organization types involved	Municipalities and informal sector, micro-enterprises, or community-based organizations. Increasingly private sector contracts.	Municipal authorities with large informal sector, micro-enterprises or small enterprises (SMEs), or community-based organizations	Municipal authorities with large informal sector, micro-enterprises or small enterprises (SMEs), or community-based organizations

2 Research Objectives & Design

This section describes the research objectives of this thesis, the specific research questions, the design, and the research methods used. The first section provides a summary of background and rationale from which the research needs are derived. Subsequent sections then specify research objectives and research questions before explaining which approach, research design and methods were used for the different tasks. Limitations of the research conducted are discussed in a separate section leading to open issues and described pathways and needs for further research. The section ends with a chapter on the structure of this monograph, guiding the reader through the content by section and chapter.

2.1 Rationale for this Research

Decision-makers in solid waste at the local government level in urban areas of low- and middle-income countries are struggling to solve the problems of solid waste management. Existing solid waste services and infrastructure are often dysfunctional or lacking, severe environmental pollution is the consequence, and the low-income population suffers most.

Sophisticated technologies as used in high-income countries are often considered by decision makers in low- and middle-income countries as state-of-the-art to strive for. Ultimate objective is to replicate these solutions without considering costs, required skills, education, and technical expertise. In their desperate situation, decision makers often believe forceful ‘‘sales representatives’’ from the private sector promoting one technical solution as the best to solve “all” problems; these miracle solutions are called “silver bullets” (Nippon Koei Co. Ltd., 2008). Information provided by such interest groups however, is most often biased to only show the special merit of a particular system or technology and disregards the risks and disadvantages and very seldom considers the specific local conditions. As decision-makers often lack technical and engineering expertise and a good overview or the current state-of-the-art in waste management, they are often uncertain about what to believe (Predehirt and Walsh) and may follow these private sector recommendations. Subsequent failures set back the municipality in terms of finances, image and trust by the residents in their municipalities and also delay the achievement of an appropriate solution. Similarly also international or national NGOs, which are either driven by their philanthropic objectives or their civil activism, frequently lack the best expert knowledge on solid waste issues and potential appropriate solutions. Often working at grass-root level with residents, they may initiate community-based solid waste projects. However, this may happen with limited knowledge of past experiences of success and failures elsewhere and thus they tend to either repeat a similar learning process or worse, to make the same mistakes as others before them which lead to failure of the project.

Experts knowledge and experience of the last 30 years has shown that relying on technological solutions it is not enough. Technology is only a small part of the larger picture towards sustainable solid waste management. Rather, an integrated approach

is necessary, which considers social, economic, institutional, legal, technical and environmental issues and tries to balance these to obtain best practicable means to manage waste. This holistic approach is embedded in the concept of "Integrated Sustainable (solid) Waste Management (ISWM)" which is now more or less accepted and acknowledged by governmental authorities. Nevertheless technical choices and an infrastructure and engineering dominated entry point are still the current practice within planning and implementation (Van de Klundert and Anschütz, 2001). One reason for this is that it is easy to understand the concept of an integrated approach but when it comes to implementation it becomes quite complex and difficult to put into action.

"Knowledge brokerage" – which highlights the importance of knowledge sharing and transfer – is cited frequently in sustainability discourses. This process of mutual learning, where policy makers and experts exchange knowledge on the issues of common concern, are considered key to improving coordination and decision making (Schübeler, 1996; Sudhir et al., 1996) In fact, a wide range of literature promotes this concept as one way of breaking down the barriers that hinder sustainable development (Sheate and Partidário, 2010; Ward et al., 2009). Decision-makers must and want to learn from successful cases. Understanding why they work, translating this knowledge and applying it to their local contexts is the clear way forward (Collivignarelli et al., 2007; Diaz et al., 2007; Read et al., 2007; UNEP, 1996; UNEP and CalRecovery, 2005; Wagner et al., 2007). A study from South Africa on the relationship between waste data availability and resulting knowledge and action has shown that knowledge and experience of waste managers is obtained predominantly through exchange and learning from others (Godfrey et al., 2012a, 2012b).

Despite the deficiencies in solid waste management and the frequent failures of projects, there is also positive evidence in the solid waste management sector that can and must be shared. If documented systematically and specific to the developing world it can significantly contribute to mutual learning. Such success stories often developed using the framework of "Integrated Sustainable (solid) Waste Management" (ISWM) have resulted in what we can call "best practices" which have a high potential for replication in other cities. Precondition for mutual learning and replication however is, that such best-practices are systematically analyzed and documented to help maximize the learning outcome. Gaining access to unbiased, well-analyzed and clearly structured information from low-income countries cases is still a major challenge within the solid waste sector. Traditionally, assessments of a waste facility or technology have focused on technical aspects only, where performance in terms of service coverage, waste volume processed and associated environmental impacts are described. The available descriptions elaborate only on what infrastructure is present, show mass flows and technical specifications. However, there is very limited information about why the project performs as expected or how the project was conceived and how and why it was able to establish itself successfully. Project appraisal may follow a multitude of well recognized approaches using a wide range of methods and tools. The impact of a specific project may be measured with indicators related to environmental pollution, social development, poverty reduction and/or improved livelihoods (African Development Bank, 2003; Rietbergen-McCracken and Narayan, 1998). These assessment methods however do not reveal how the quality of service or project

performance (i.e. success) is affected by the specific contextual conditions also called ‘‘enabling environment’’ (Lüthi et al., 2011). In this regard, a need for methodological improvement has been identified (Zurbrügg et al., 2012).

There is a need for research to:

a) Identify methods which help assess the enabling environment before a specific intervention
b) Further develop methods of assessment which assist the decision-maker in evaluating a specific solution in terms of feasibility and expected impact
c) Provide a framework and structure to document lessons learned not only with regard to the result and outcome but also to better understand the process and development of the successful project.

2.2 Research Objectives

The overall objective of this thesis is to assess existing favorable framework conditions for sustainable solid waste projects in low- and middle-income countries and provide support to a wide variety of stakeholders so that they can improve the planning, design, implementation and continuous adaption of waste projects and thus contribute to sustainable development.

This overall objective is reached through:

A) Analysis of current assessment frameworks and methods, and the evaluation of their merits and demerits to determine their appropriateness for use in low-income country conditions.
B) Study of literature and solicitation of expert information on the factors of success and failure of past solid waste projects in low- and middle-income countries to identify technical, social, economic, institutional and environmental determinants needed to ensure the sustainable implementation of solid waste implementation activities.
C) Structure sustainability elements systematically to develop a questionnaire based assessment tool.
D) Validate, verify and adapt the developed assessment tool in case studies.
E) Develop guidance on which key factors and project conditions enhance sustainability of solid waste projects in low- and middle-income countries and how these can be considered in the project planning cycle.

The primary target audience for the outputs of this thesis is academia. However for the practical application of the questionnaires and guidelines developed, the target audiences are NGOs, private enterprises, city planners and development agencies. The methods developed and knowledge obtained through this research shall help implementers understand key conditions required to improve their planning and operation of projects to achieve more successful and sustainable projects. Academia can benefit from this research either by using the developed tools to systematically assess and understand strengths and weakness of projects which are comparable to each other, and through this establish more evidence-based knowledge. In addition, academia can further develop methods and tools to enhance the use of holistic and

integrative approaches and modeling which take into account the diverse dimensions of sustainability.

2.3 Research Questions

Given the objectives as outlined above, the research questions of this thesis are comprised of the following:

A1) What assessments methods exist? What are their strengths and weaknesses and how have they been applied to solid waste management projects in low- and middle-income countries?

B1) What are the factors that influence and determine success or failure of solid waste projects? Can generic themes and criteria be identified, which are valid independent of solid waste project type?

C1) What tools and guidance can be developed to assist evaluators of existing projects or planners of future projects?

D1) How do these developed tools and guidelines perform when used in specific case studies?

D2) Do the case study assessments confirm the importance of the previously established factors of success and failure and, if required, how must these be adapted to be more comprehensive?

E1) What key factors should be considered to ensure sound planning and implementation of a solid waste project in low- and middle-income countries?

E2) How and what combination of tools and methods can be used to assist with the planning of solid waste projects in low- and middle-income countries?

2.4 Research Approach and Methods

The research approach was derived from the author's past 14 years of research experience with solid waste projects in low- and middle-income countries and the observed frequent failures of projects initiated by municipalities, community-based organization or non-governmental organizations. Thus this research is based more on a deductive approach (Hyde, 2000). Gathering a wide range of existing knowledge on methods of assessment and a qualitative description of ''drivers of success'' or ''reasons of failure'' in solid waste projects led to a formulated hypothesis which is then verified and validated in the case studies. In the cases studies, analyzed by the author, predominately qualitative data is collected and the cases serve to amend and adapt the assumptions and hypothesis. The case studies predominately describe and analyze the situation rather than evaluating the variety of possible future solutions. Furthermore they are analyzed by the author in close collaboration with the case agents, and an objective scientific attitude is taken towards the case (Scholz and Tietje, 2002). For each case the main objective is not to find the best practicable solution for a specific location and field site but rather use the case to assess and validate the assumptions of factors affecting success and failure. There is therefore a clear distinction from an exploratory action research approach (Di Bella, 2010).

The theoretical framework of this thesis is rooted in the integrated sustainable (solid) waste management approach (ISWM) as described in an early stage by Schübeler in his report on "Conceptual Framework for Municipal Solid Waste Management in Low-

Income Countries" which was then further refined and documented by Van de Klundert and Anschütz in 2001 (Schübeler, 1996; Van de Klundert and Anschütz, 2001). Feeding into this framework of integrated approach are theories and conceptual thinking around the capability approach (Robeyns, 2005), social capital assessments (Bowles and Gintis, 2002), sustainability assessments (Pope et al., 2004; Singh et al., 2009), business and project management, reliability and maintainability management (Madu, 2005), strategic and marketing planning (Griffiths and Wall, 2004; Gillespie, 2007), and technology assessment (UNEP-IETC and HIID, 1996; Olschewski et al., 2011).

The first step in the research approach was to compile knowledge and experience from researchers and practitioners related to the low- and middle-income context. This was achieved through literature study, semi-structured interviews and targeted workshops. A European Community (Framework Program 7) funded project called ISSOWAMA (Integrated Sustainable Solid Waste Management in Asia) provided an ideal entry point to solicit expert knowledge (ISSOWAMA, 2009). The consortium of 17 partners, including 12 from Asia and 5 from Europe (of which the author was one of the European partners) had set themselves the task to identify the challenges and opportunities of solid waste management in Asia. Through workshops and moderated electronic exchange the consortium jointly developed assumptions on key determinants of solid waste management which were then particularized through a preliminary assessment tool formulated as a set of questions. The result was a simplified method to assess solid waste projects through a series of questions, with a systematic structure of thematic domains and issues which provided the basis for analysis of the ''drivers of success'' or ''reasons of failure''. This assessment tool links closely to the integrated sustainable waste management approach (ISWM) as defined and described by Van de Klundert and Anschütz (2001) and is supplemented with aspects of project management, and analysis of the enabling environment as identified through literature and discussion with other experts (Van de Klundert and Anschütz, 2001). Experience gathered from environmental sanitation projects were also considered for this framework under the assumption that the similar typology relating to the provision of urban environmental services justifies this. As one step of the ISSOWAMA project, the predominately qualitative assessment tool was then tested by local researchers, solid waste specialists as well as the author in countries of the Asian region. The tool was used to assess cases which, in the specific country context were identified as "best practices" and did not restrict to any specific aspects of the solid waste management system. This "testing" of the assessment tool allowed experts to give feedback on the usefulness of the assessment questionnaire and suggest changes. A total of 19 cases were analyzed from 8 Asian countries (ISSOWAMA, 2010). The main methods used for the assessment of these 19 cases were:

- analysis of document, including a systematic search for comprehensive information, evidence or insight out of documents directly or indirectly related to the project,
- individual semi-structured interviews (face-to-face or by telephone) with selected stakeholders,
- direct observations.

Concurrently to the development of the assessment tool as described above, a literature review studied existing assessment methods currently in use (ISSOWAMA, 2011b). The goal was, on one hand, to provide an overview of methods typically used

in the solid waste sector but on the other hand to study which ones have been applied to the solid waste as well as developing country context. The overview is structured according to the type of impacts assessed (i.e. technical, environmental, economic, social, institutional/organizational, and legal).

Case study: Waste Composting in Gianyar, Bali

In addition to the assessment conducted by local researchers in the framework of the ISSOWAMA project, for the case of municipal waste composting in Gianyar a more detailed assessment was conducted by the author and published in (Zurbrügg et al., 2012) as part of this thesis (Chapter 7 and Annex 5). This more in-depth assessment of the case study in Bali by the author relied on a first version of the above mentioned ISSOWAMA assessment tool which was adapted by the author. The main changes made to the original version were done to include the development pathway to thus avoid the assessment of a snapshot in time. Such a historical and trend analysis seeks to further systematically understand the processes and events that led to a current situation or context and gives an indication of how the project wants to develop in future and studies what mechanisms are in place so that this can be achieved. The assessment followed a guiding set of questions covering the different sustainability relevant thematic areas which include: technology, social aspects, economy, institutions, and environment. The assessment questionnaire consists of a mix of qualitative and quantitative data requirements. Indicator questions included in the assessment questionnaire can be answered either with: ‘‘no’’, ‘‘rather no’’, ‘‘rather yes’’, ‘‘yes’’ or ‘‘not applicable’’. Some questions allow for a qualitative descriptive answer. Finally also open questions are included to obtain information from respondents to highlight important aspects not covered elsewhere in the questionnaire.

In the case of Gianyar Bali, the method of inquiry and data collection combined a variety of research tools and methods.

- *Document analysis:* This was comprised of a systematic search for information, evidence or insight from documents directly or indirectly related to the project. With the Gianyar composting unit, a large benefit for the assessment was the very comprehensive project documentation.
- *Direct observations:* This involved a site visit to the composting facility and observation of the solid waste management situation *in-situ*.
- *Semi-structured interviews:* The author conducted semi-structured 2-3 hour interviews with three key informants and documented direct observations at the site. Interviewees were the initiator of the project, the chief technical officer and the marketing and the communication specialist. Four months after these first interviews a local researcher of the University of Indonesia in Jakarta visited the composting unit and conducted a semi-structured interview with the initiator of the project. Data from both assessments were compared and did not differ significantly, which proves the replicability of the assessment. After six months the author conducted additional two unstructured interviews with consultants from an international development bank who had just visited the composting unit and interviewed staff.
- *Historical and trend analysis:* This aspect was integrated as questions for the semi-structured interviews. This involved understanding the processes and

events that led to a current situation or context, using methods such as historical narratives, timelines and time trend analysis.

All site visits, interviews, assessments and analysis were conducted inside a period of about one year.

Case study: Primary Waste Collection in Managua

The assessment of the case study in Nicaragua (Chapter 8) relied on a further developed version of the assessment tool (Chapter 6). The initial assessment started with an open-ended interview with a project officer from a multilateral development organization after his presentation of the specific case at a symposium. Based on this preliminary information the case was esteemed to be suitable for further assessment as a "best practice" case and the tentative decision was made to follow-up with a further analysis and field visit. Online research, document analysis and exchange with experts in Nicaragua followed to better establish the scope of analysis which then resulted in the decision to focus on various examples of primary waste collection schemes implemented in the city of Managua. During a field visit in 2012 the following methods were then used to gain detailed insight into this case:

- study of project documents, public documents of the municipality, project presentations and dissemination materials, as well as online magazine and newspaper research.
- direct observation at 6 specific locations in Managua: three transfer and recycling centers, the main landfill, and two cooperative centers.
- semi-structured interviews with one leader of a waste collection cooperative, two microenterprise owners engaged in primary waste collection, one resident serviced by a primary collection enterprise, 5 project officers of various supporting agencies, one head of transfer station and the director of municipal solid waste management.
- three semi-structured group interviews, one with a community association (3 representatives), one with a waste collection cooperative (4 representatives present) and one with municipal staff at the transfer station (5 staff).

Elements of the Delphi Technique were used during the interviews with individuals and groups (Yousuf, 2007), where in a second phase of the interview expert opinions gathered from other interviews were presented to the interviewees and adaptation of views solicited. The preparation, site visit, interviews, assessments and analysis were conducted in a total period of approximately 3 months.

Case study: Primary Waste Collection in India

This case study involved a retrospective analysis of a previously conducted survey of Indian community initiatives in solid waste management. All raw data is derived from interviews conducted during the research project "Decentralised Composting in Indian Cities" (Zurbrügg et al., 2004). The goal of this past project was to determine the success factors and obstacles of decentralised solid waste collection and composting schemes in order to define new strategies for supporting such schemes in the future. South India was selected for the study given the personal contact with two very knowledgeable people connected to many composting initiatives. The area has a very active composting scene which includes commercial enterprises, public organisations

and community initiatives. Representatives from twenty composting schemes of varying size, organisational set-up and scope were interviewed. Interviewees were mainly the initiators of the schemes and in one case also the supporting municipal officer of various neighbourhood initiatives. The semi-structured interviews addressed organisational, technical, financial and social issues in order to draw a full picture of each scheme. The survey covered not only questions to assess the current status of the composting scheme, but also the start-up process and future prospects as perceived by the interviewed persons. In this way it was possible to retroactively analyse the collected data with a new focus on resilience, using the five assets of the Sustainable Livelihood Framework, and the four factors of Protection Motivation Theory. Out of 20 solid waste management schemes, the analysis concentrates on eight community-based schemes, three each in the cities of Bangalore and Mumbai and one each in Chennai and Pune. The analysis applies three different conceptual approaches to describe how motivation, social capacity and access to assets influences community initiatives and how these elements affect sustainability and success. These are: Protection Motivation Theory, The Resilience Concept, and the Sustainable Livelihood Approach. The concepts are explained more in detail in the Chapter 4 on "assessment methods".

Case study: Waste Composting in Dhaka

The assessment of the case study in Dhaka, Bangladesh on waste composting relied on the newly developed assessment tool of this thesis. Data collection was conducted during the period of 2011 and 2012 by the author and was comprised of the following inquiry methods:

- Literature and secondary data collection included a systematic search for information on the composting experiences in Dhaka and elsewhere in the region as well as the overall solid waste situation in Dhaka. Historical analysis furthermore allowed to grasp the development over time with description of specific events that led to a change in situation or context.
- Two semi-structured, 3 hour interviews were held with the main initiators of the project. These key stakeholder have unique knowledge and experience not only with the case itself but also on the overall solid waste situation in Dhaka and the trends and development in the national policies and legislation of Bangladesh with regard to solid waste management.

Results were structured according to the developed and proposed assessment format for reporting. A first draft of an excel-based software assessment tool was developed and tested on this case study.

Case study: Infectious Waste Management in Bangkok

The assessment of the case study in Bangkok, Thailand on infectious waste management also relied on the above mentioned assessment tool as a starting point but then extended the questionnaire to integrate other methodologies. A special focus was given to stakeholder analysis and interactions among stakeholders using methods of social network analysis (Caniato et al., submitted). The data collection was conducted by Marco Caniato, a doctoral student at the University of Brescia, during a period of one month in June 2011 and was comprised of the following:

- A systematic search for secondary data and subsequent document analysis. Data obtained from secondary sources such as documents and reports ,were crosschecked with newer documentation and through specific questions in the interviews.
- Personal observations on-site.
- Key informant interviews to identify the main stakeholders and the main elements of the waste management system including the historical development.
- Semi-structured interviews with selected key stakeholders to assess the waste management system, stakeholder interests and power relationships, and networks among stakeholders.
- Key informant interviews with individuals that have unique knowledge/personal experience of the investigated issues.
- Stakeholder analysis
- Focus group discussions with stakeholder groups; whereby a SWOT analysis was used to understand the Strengths, Weaknesses, Opportunities, and Threats of the project to be assessed (Trochim, 2006).

2.5 Limitations

The focus of this thesis is neither on one specific element in the service chain of solid waste management nor on one specific technological approach. The case study analysis takes into account different functional elements such as primary waste collection, treatment by composting and infectious waste treatment by incineration. It also considers the countries such of Indonesia, India, Thailand, Bangladesh and Nicaragua. Although the variety of countries is large it is obvious that not all the specificities of solid waste management approaches and the respective regional socio-cultural and economic differences are represented.

Literature review is used to cover more variety of solid waste system elements and countries and an exchange and dialogue with experts from other regions attempts to mitigate this constraint.

Here the focus is set on waste management in urban settings where the main responsible authority is the local government, most often represented by the municipal waste management services. The situation of dispersed rural areas or the management of special wastes from certain economic sectors (mining, agriculture, industry) or specific locations (ports, military camps, industrial zones, etc.) are not taken into account.

Not all existing assessment methods in the wide array of disciplines were taken into account in the overview and analysis. The limitation was given due to time available and the scope of this thesis. Given the sheer number of methods, it was not easy to obtain the most updated knowledge at all levels. Especially the academic domain shows a dynamic development of new or existing methods, however the practicability of many methods remains restricted to academia and research purposes. It can be observed that new methodological developments are seldom used or tested in the solid waste sector and if at all, then hardly ever in the context of low- and middle-income countries.

This research recognizes and accepts these limitations and the author argues that it is an attempt to identify the overall applicable aspects which are relevant in all steps of a solid waste service chain independent of geographical region but nevertheless specific to the situation in low- and middle-income countries. The thesis further argues that the identified factors of success, especially if not linked to technical issues, are crosscutting in nature and are thus valid for a large range of options and geographical regions. Nevertheless this hypothesis still needs to be verified and validated with more case study assessments which will be the object of future research.

With the development of tools for practitioners it is not trivial to balance between being simple and easy to use, but nevertheless detailed enough to obtain relevant projects insights. The tools developed during this thesis, were designed to ask questions on what is considered to be the most important information. Nevertheless, from a field perspective, the researcher must also recognize that at times it might be difficult to obtain access to such data, which on one hand may not even be available at the assessed facility or might be considered confidential, especially in cases where the activity takes a business approach and information is considered as a competitive advantage.

The questionnaire developed does not help prioritize issues. Understanding which factor is more important than the other cannot be achieved with a generic questionnaire. Ranking and weighting of criteria is a task which can be conducted with local stakeholders. Some indication of methods and tools are highlighted in this thesis.

The way the questionnaire and assessment tool is designed is not a planning instrument. It is devised to analyze existing waste management activities and from this perspective is a helpful tool for monitoring and evaluation. The tool does not compare different treatment technologies and therefore does not provide decision support on technology choice. However with the description of important conditions and requirements which influence project success, the issues raised can be matched to what the technology and project approach can or cannot fulfill and thus can help with the filtering of options and in making a choice. Once a project has been selected with a technology approach, the critical issues as listed in the questionnaire will be highlighted and may serve planners and decision makers as a checklist of issues to think about when developing and moving forward the project. This was taken into consideration when developing the tool for planning as described in Chapter 6.4.

Results from the questionnaire which are mainly based on observation, provide a snapshot in time. To compensate for this, questions were integrated which shall give insight into the dynamic development of the case over time. As all activities undergo continuous development and change it is the pathway and direction of change which gives important hints regarding the achievement of sustainability.

2.6 Structure of the Thesis

This thesis starts with by introducing the reader to the overall issues of solid waste management, in Chapter 1. It elaborates on the definition, the key elements, stakeholders and the effect and impacts of deficient solid waste management on humans and environment. Special attention is given to solid waste management in developing countries and how this differs to more affluent countries. Following this introduction the author then clarifies the research objectives and how the research process was designed and conducted. The research and inquiry methods are then described for each of the five case studies analyzed. Chapter 3 and 4 then directs attention to assessment methods for decision support. Chapter 3 clarifies terminology as well as the scope and potential of assessment methods/tools and their use in solid waste management projects. Chapter 4 follows by introducing existing assessment methods structured by thematic fields, also called "sustainability domains". Here merits and demerits are described and results from literature review show how and where these method/tools have already been used in developing countries and for the topic of solid waste management. What can be learned from failures and success of solid waste project in developing countries follows in Chapter 5 which is based on the review of academic literature and reports. Extracting and summarizing the gained knowledge from Chapters 3 to 5, leads to the development of an alternative assessment approach that is presented in Chapter 6. This proposed assessment tool was applied in five case studies in combination with other assessment methods. The results are presented in Chapter 7 to 11. To conclude, Chapter 12 summarizes the research results and knowledge gained, while Chapter 13 looks forward and identifies where there is need for more research following in line with this thesis.

PART 2

3 Using Assessments to Foster Sustainable Solutions in Developing Countries

Providing good and safe solid waste management is one of biggest challenges of the ever-increasing urban areas, which are already home to more than half of the global population. The issue is often in the top five rankings of major challenges for city managers (Scheinberg et al., 2010). Decision-makers and managers of solid waste services are struggling to find appropriate solutions to solve the problems. Often solid waste services and infrastructure are lacking or dysfunctional and serve only the wealthy residents. Severe environmental pollution is the consequence of deficient waste management and the urban poor suffer most. The failure to improve the situation set back the municipality in terms of finances, image and trust by the residents, making it even more difficult to devise a way out of the dilemma.

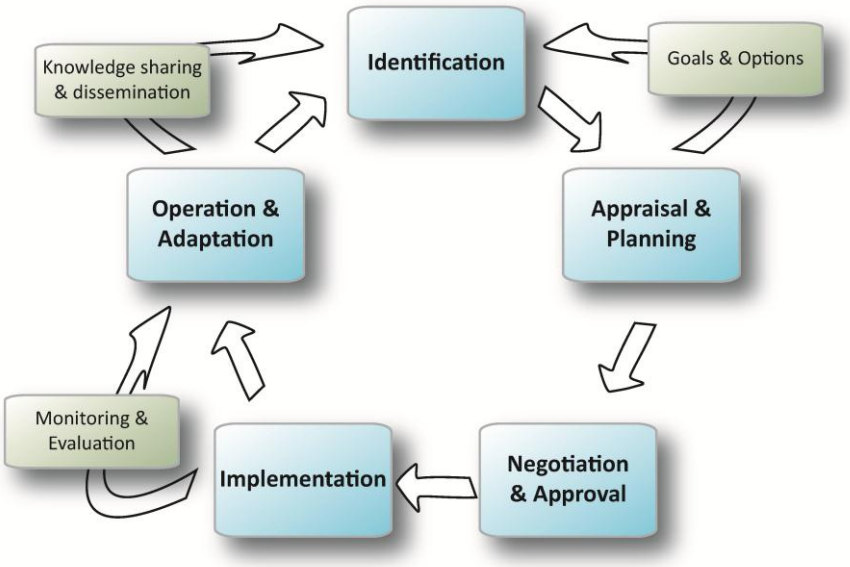


Figure 5 The project cycle where assessments (in the green phases) can support decision making.

But not all is lost. Many low and middle country cities have found ways to upgrade and provide sustainable services. However, this information and knowledge remains local, often undocumented and is not accessible to the outside world where there is a dire need and demand for such knowledge. A range of literature discusses the concept of mutual learning. This is promoted as a way of breaking down barriers that hinder sustainable development (Zelenika and Pearce, 2011; Sheate and Partidário, 2010;

Ward et al., 2009; Wilson et al., 2007). With this decision-makers can make a first step to learn successful cases, understand these and translate and apply them to their local context (Collivignarelli et al., 2007; Diaz et al., 2007; Read et al., 2007; UNEP, 1996; UNEP and CalRecovery, 2005; Wagner et al., 2007). They are also looking for unbiased assistance, by experts or help of easy applicable tools to support decision making, early in the project cycle (Figure 5) – between identification and appraisal - in order to make the right choices when developing strategies or planning investments.

This is where assessment methods enter into the picture. They can help ensure a structured way of thinking and a comprehensive method for data collection and analysis. Furthermore, by using a systematic and defined methodology they can ensure objectivity and replicability.

In this thesis, the explicitly identified reasons for using and further developing assessment methods for decision support are twofold:

a. By using well-defined assessment methods on existing cases we can analyze their performance/impact (in all sustainability dimensions) and understand how and why the performance/impact is as it is.
    I. Each case assessed and analyzed can help identify the specific weaknesses in that moment of time. With the identified weakness mitigation measures can be evaluated and implemented to rectify the situation and improve performance of negative impact.
    II. Using a standardized methodology on different cases allows them to be compared. With a large number of cases assessed, the information obtained can help establish some general valid factors of performance success or failure in projects. This knowledge can then help decision makers avoid the same mistakes others have already experienced or highlight how specific risks during project development and planning can be avoided early on.
b. Using assessments for prospective analysis of project scenarios can help in evaluating and comparing between options, be this different financing models, technology elements and/or organizational setups.

This differentiation in case study analysis is described in Scholz (2002) with the Table 6 as shown below (Scholz and Tietje, 2002).

Table 6 Four categories of methods for embedded case studies depending on scope and point of view, adapted after (Scholz and Tietje, 2002)

	description of the problem or case	evaluation of possible solutions
Practice	Case description from study team point of view	Case evaluation from the project planner point of view
Research	Case description from researchers point of view	Case evaluation from researchers point of view

In all approaches the scope of assessment and analysis may vary. Historically assessments for solid waste facility management had a strong focus on technology selection and evaluation. The variables analyzed comprised performance indicators (e.g. waste amounts processed, energy consumption, etc.) as well as cost (e.g. of investment and operation). With increasing realization that a technology view alone does not stratify the complex demands of integrated and sustainable solid waste management (Schübeler, 1996; Pires et al., 2011a) a variety of systems engineering models and system assessment tools were designed (Chang et al., 2011). Disciplinary domains of business economics, environmental science, engineering and social science link together to form a more holistic approach. Chang (2011) structures methods and tools into three categories of: a) systems engineering models which includes cost-benefit analysis, forecasting analysis, simulation analysis, optimization analysis; b) systems analysis platforms, such as management information systems/decision support systems/expert systems; and c) system assessment tools which includes scenario development, material flow analysis, life-cycle assessment, risk assessment, environmental impact assessment, strategic environmental assessment, socioeconomic assessment, and sustainability assessment.

Finnveden et al. (2007) on the other hand characterize the different methods by developing a typology based on three criteria: (1) type of impact assessed; (2) object under study, site or non-site specific; and (3) procedural or analytical method (Finnveden et al., 2007). Similarly, van Buuren and Potting (2011) have compiled an overview of assessment methods for the Asian context in the framework of the EU-FP7 funded project “Integrated Sustainable Solid Waste Management in Asia (ISSOWAMA)” (ISSOWAMA, 2011a).

Most assessment methods focus on the subsystem level, to evaluate a certain technical element in a system (e.g. a composting facility) with its respective requirements, performance levels and impacts. The same methods may also tackle the full system by integrating all individual subsystems to a whole, whereby the task is thus much more complex and is often used to assess impact of a given choice (Chang et al., 2011). Another aspect to consider is which criteria and impacts are assessed. The criteria areas often link to a disciplinary expertise which can be dissected with help of the overall sustainability framework into the three pillars of social, economic and environmental sustainability.

3.1 Clarifying the Terms “Integrated”, “Sustainable” and “Feasible”

The need for clarification of these terms seems necessary as often in literature they are used interchangeable and at different levels of generalization (Chung and Lo, 2003).

3.1.1 Integrated Waste Management (IWM)

In the past, in its simplest understanding, the meaning of “integrated” was taken to mean all system elements in waste management such as generation, storage,

collection, treatment and disposal. This rather technocratic view was subsequently revised to a more "system" understanding where the system is described as a group of interacting elements that form an integrated whole intended to perform some function (Seadon, 2006) whereby "the problems are multidimensional and multidisciplinary and so the solutions must reflect this complexity". UNEP-IETC (1996) further defines integrated waste management as a structure of reference which serves to design and implement new waste management systems and to analyze and optimize existing systems (UNEP-IETC and HIID, 1996). Pant (2000) (cited in Chung and Lo, 2003) in his definition, embraces the idea that IWM includes all waste streams and also the time dimension but continuously monitoring and improving the solid waste management system. Integrated sustainable (solid) waste management (ISWM), as described by Van de Klundert and Anschuetz (2001) makes a distinction between its elements (the infrastructure), the stakeholders (the humans interacting) and the "aspects", which is the term used for the enabling conditions or "societal context". The aspects can be seen as special lenses with which the existing waste system is analyzed and integrated holistic planning can result (Van de Klundert and Anschütz, 2001). The enabling conditions are societal fields of interest which have an influence on a waste management system but which in turn can also be impacted by the specific project. This concept is very close to the notion of sustainability as explained below.

3.1.2 Sustainability in Waste Management

The idea of "sustainable solid waste management", similarly to the ISWM concept of Van de Klundert and Anschuetz (2001), implies the integration of technical, environmental, socio-economic, institutional, legal, political, and even cultural dimensions. Such elements are further discussed in Cointreau (2001) where the "Declaration of Principles For Sustainable and Integrated Solid Waste Management" (Cointreau, 2001) are listed. These comprise:

- Good Governance (accountability, transparency, equity)
- Economic Service Delivery (cost efficiency, affordability, budget allocation)
- Financial Sustainability (cost recovery mechanisms, cash flow)
- Natural Resources Conservation (resource consumption)
- Public Participation (participatory dialogue, awareness raising)
- Environmentally Appropriate Technologies and Sites (minimize impact, monitoring emissions)
- Source Segregation, Recycling and Resource Recovery (integration of recycling, markets for recyclables)
- Strategic Planning and Development (forward looking)
- Capacity Building (staff skill development)
- Involvement of Private Sector Actors (integration of alternative actors)

The notion of sustainability is closely related to that of success. Typically, the distinguishing feature is the time dimension where success can be understood in a shorter timeframe whereas sustainability refers to a long term enduring success. In this thesis, the terms are used interchangeably as the time dimension is defined by the useful life time of the project and its project succession, so a sustainable project is equal to a successful project.

Sustainable waste management should however, not be confused with the term sustainable development which goes far beyond only waste management but includes all human-ecological interactions. The concept of sustainability was initially introduced with the *Brundtland report* of 1987 published by the World Commission on Environment and Development: Herein it is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (United Nations, 1987). By understanding this notion of sustainable development, it is obvious that sustainable waste management is one pillar of sustainable development (Ashley et al., 1999).

Applied to a solid waste management project or activity, the term *sustainable* describes an activity, project or management system that fulfills the goal of the activity while ensuring a high quality of life, social equity, economic integration and environmental protection in order to respecting the needs of future generations. Sustainable projects and activities are thus committed to environmental, social and economic health (also called the "triple bottom line") and by achieving these goals can endure over time. Achieving such broad goals, often involves assessing and compromising on inherent trade-offs among the specific *dimensions of sustainability* and are usually a balancing act. Positive developments in one area can affect practices or activities in another area either in a reinforcing or also in a counteracting way (UNEP and CalRecovery, 2005). Structuring, analyzing and understanding these various conflicting needs is a first step. This happens at various phases of the project cycle, from an initial stage of problem identification, to the stage of planning and design as well as operation, monitoring, adaptation, and finally including also the stage of decommissioning.

The concept of "enduring over time" is another aspect that is often set equal to the understanding of sustainability, as typically the words "to sustain" implies. Carter et al. (1999) describe the understanding of sustainability, in the sense of a continued delivery and uptake of services, which may be threatened by numerous attitudinal, institutional and economic factors (Carter et al., 1999). On a similar level of understanding the term longevity is used, where this reflects the capacity for long-term continuance, as well as users' ability to use and benefit from it for a substantial period after external assistance has come to an end (Roma and Jeffrey, 2011). Roma and Jeffrey (2011) use such an approach for technical sustainability assessment where, on one hand the technology is assessed from a "technical specifications" point of view, and on the other hand from assessing the experience and perceptions of the user of technology. The disparity and understanding between the nature and reasons behind the gap can then provide guidance for ensuring sustainable appropriation and change. In McConville and Mihelcic (2007) the understanding of sustainability - similarly to Roma and Jeffrey (2011) - encompasses longevity by developing project sustainability factors, common in development literature and the policies of international aid organizations (McConville and Mihelcic, 2007). These are: (1) sociocultural respect, (2) community participation, (3) political cohesion, (4) economic sustainability, and (5) environmental sustainability. The Water and Sanitation Programme (WSP) of the World Bank and its specialist adviser move one step further along the notion of project

sustainability to develop dimensions that are considered essential to the scaling-up, sustainability and replication of projects (Robinson, 2008).

Such a notion of sustainability is very often embedded in development cooperation projects, when sustainability is set equal to self-reliance and durability. One could argue that without adhering to the principle of the "triple bottom line", then also longevity cannot be ensured. However many cases can be brought forward where longevity of projects is sustained although these seriously endanger one dimension of sustainability, for instance the environment.

When looking through academic literature on solid waste management issues, authors use of the term "sustainability" in a very flexible and imprecise way. Predominantly it is used either for the specifics of environmental sustainability or else as a broad concept of a good and enduring system which fulfills the goals of providing service to all residents. In development cooperation the understanding is rather focused on the project life-cycle, ensuring that the development activity continues after the project comes to an end and is "handed over" to the local actors.

3.1.3 Feasibility in Waste Management

The study of feasibility is derived from a business perspective. Feasibility studies have the goal to objectively expose strengths and weaknesses of a business idea, proposed venture or proposed change to the system (USDA, 2000). Furthermore, opportunities and threats of the external environment as well as the required resources are studied to then eventually evaluate the potential of success.

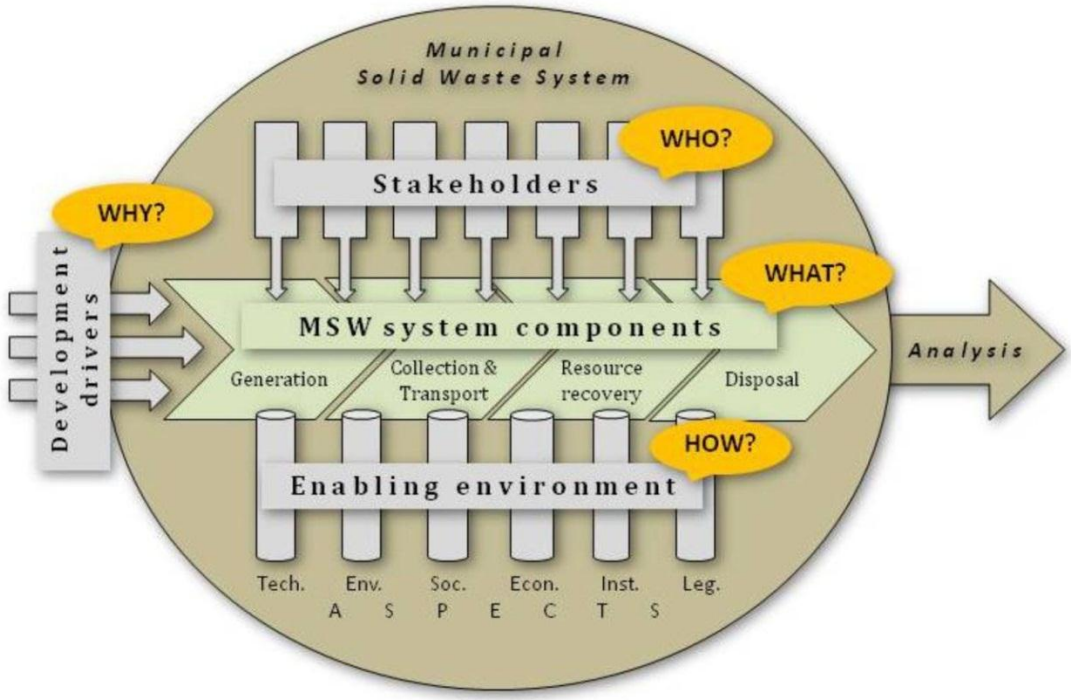


Figure 6 Framework of analysis for feasibility assessment developed for anaerobic digestion (Lohri, 2012)

Viability and profitability are one of the major indicators of success (Small Business Development Cooperation, 2012). Typically a feasibility assessment is comprised of: technical, economic, legal, operational, cultural and schedule aspects (abbreviated by the acronym TELOCS). This categorization show close similarities to the frameworks of sustainability or the key aspects highlighted by Van de Klundert and Anschütz (2001) in the ISWM framework. The only exception is the aspect of environment, which from a business venture perspective is included under legal (adhering to environmental legislation) or technology and economics (e.g. saving resources through better technical processes reduces costs). To establish a feasibility assessment tool for anaerobic digestion, Lohri (2012) developed a framework which includes the aspects of the ISWM framework but goes a step further by including also motivational, so called "drivers" which characterizes "why" a certain project or venture is being pursued. The framework of analysis is shown in Figure 6 for the specific waste element of anaerobic digestion (Lohri, 2012).

In waste management, taking a business venture approach is not very common as the service or "business proposition" is categorized as a public or merit good and it is thereby not deemed necessary to include the notion of economic viability. The author strongly disagrees with this viewpoint, as even a service of public good, clearly links to technology used (thus requiring an assessment of technical feasibility) and associated costs and revenues, independent if the money to cover cost is obtained by the direct beneficiaries/customers or by state/tax funding.

3.2 Impact on Environment versus Enabling Environment

Assessment methods seldom make the distinction between: a) what influences the case and b) how the case influences the environment. Impact assessment typically focuses on the latter without looking at the feedback loop influencing societal processes.

3.2.1 Impact

Any solid waste management activity will result in an "impact", positive or negative, on the socio-economic and natural environment. Such impacts will alter the perceptions and interactions among stakeholders and this change in societal conditions can influence the "enabling environment", which either fosters or hinders the solid waste activity. This interaction is expressed well by the "pressure-state-response framework" as shown in Figure 7 (OECD, 1993). Waste management exerts pressure (impacts) on the environment thereby changing its state. This change and the perception of it importance and severity triggers societal processes at different societal levels (households, administrations, etc.) which then again results in societal responses (actions, policies, etc.). The responses affect the enabling environment for the original solid waste activity or future similar projects.

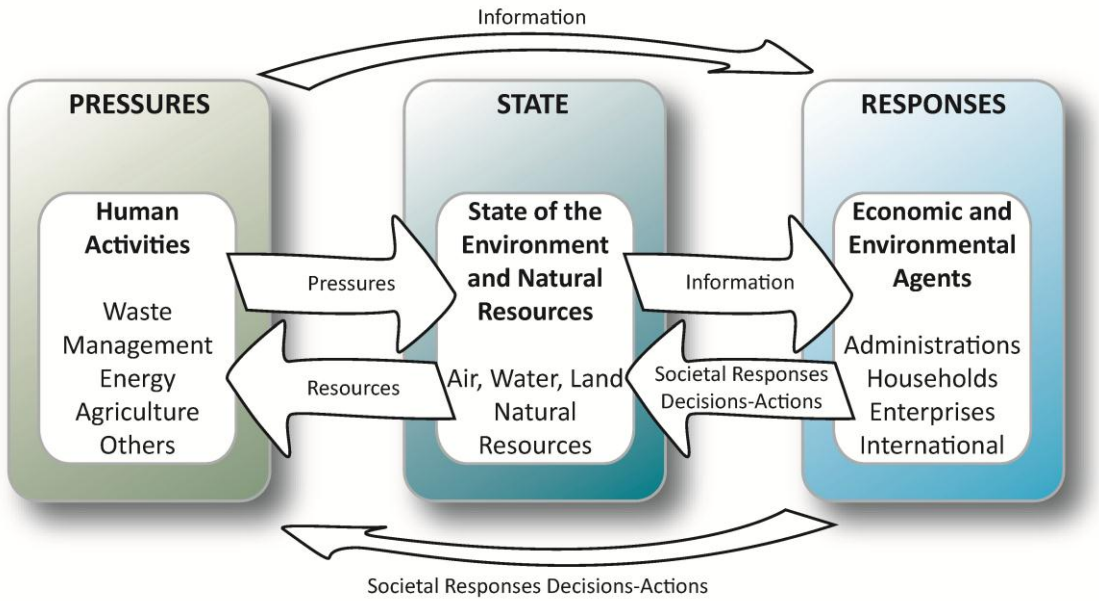


Figure 7 Elements of the pressure state response framework, (OECD, 1993).

The best example in solid waste management of such a pressure-state-response situation is the NIMBY (not in my back yard) effect. NIMBY characterizes opposition by residents to a new development for instance, a landfill or a waste treatment facility (e.g. incineration) because it is close to them (Zurbrügg, 2003). The NIMBY example also shows that societal responses are not necessarily linked to the specific impact of the proposed project but rather to the societal perception of impact based either on previous experience or obtained external information. The public resistance to a sanitary landfill is a result of past experience or information on how open dumps have impacted negatively on neighborhoods. Building of public opinion can thus, be based on information from other cities, regions or even nations.

The type of impact assessed will depend on the method used for assessment. Historically, the center of attention of any assessment was to evaluate the impact on cost, to design the most cost efficient and optimized solution which can provide the desired service (Chang et al., 2011). Then, with increasing environmental concerns, focus was set predominantly on assessing environmental impacts (Wilson, 2007). More recently, resource recovery, energy systems models and social impacts are either being further developed or integrated into existing overarching models (Chang et al., 2011).

Selected assessment methods are described and evaluated with regard to their usefulness for waste management in low- and middle-income country setting in the subsequent chapters.

3.2.2 Enabling Environment

Success of any solid waste management action needs support by a favourable “external” environment. This is called the enabling environment. Without it, the resources committed to bring about change will hardly be effective (Lüthi et al., 2011). “Enabling environment” is used as a term to describe a group of interrelated features

and conditions, which, in a specific context will set the basis for change and improvement (Figure 8). Furthermore, these features of an enabling environment will support and sustain this improved state over time. The enabling environment can therefore also be described as a set of factors impacting on the solid waste management project or activity of concern during the whole project cycle. This set of enabling conditions are dynamic and will change more or less rapidly with time. The causes for change of the enabling environment may, or may not be linked to the specific solid waste management project or "case". Economic crisis, research and innovation and the associated mutual learning process, or political change, are typical examples of a changing environment which is influenced from outside the local solid waste management domain.

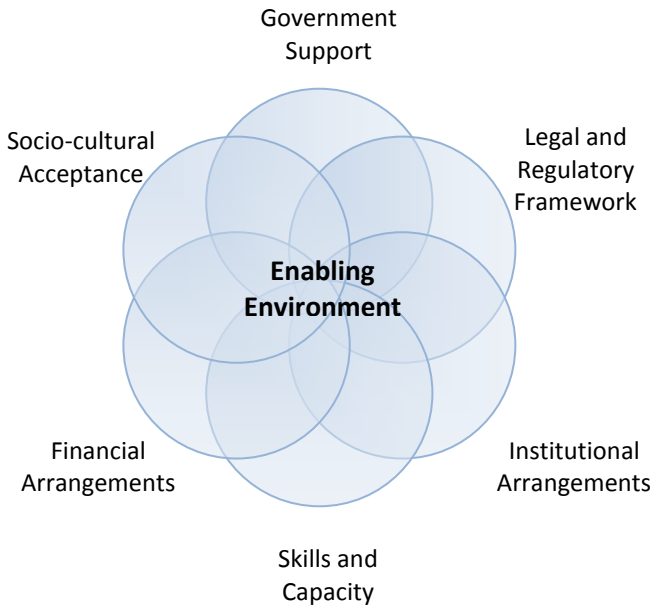


Figure 8 Interrelated features of the "enabling environment", (Lüthi et al., 2011).

Lüthi et al. (2011) distinguishes the following six aspects of the enabling environment relevant for sanitation infrastructure planning (Figure 8) which are here translated to solid waste issues:

- *Government support*: The extent to which government will support or hinder the implementation of any solid waste project. This depend on endorsement by key political players as well as coinciding with national policies and strategies for the sector.
- *Legal and Regulatory Framework*: Laws, regulations, standards and codes, within the policy framework, determine who can provide the specific waste management service; which rules and standards the services needs to adhere to; who can have ownership of waste, infrastructure and services; as well as how and what revenues (from tariffs or other cost recovery methods) can be warranted to ensure long term service. Environmental standards and codes further determine the levels of acceptable maximum environmental emissions and building codes define infrastructure, materials and equipment requirements.
- *Institutional Arrangements:* It is crucial to understand the current roles, responsibilities and capacities of the different stakeholder groups in any projected change. Here, formal and informal roles and responsibilities, attitudes,

power relationships, influence and interest need to be well understood as well as the interaction and network among these stakeholders. This helps to better build on the strengths and make use of the opportunities while devise strategies to mitigate the threats.

- *Skills and Capacity:* Any change in the solid waste management system will need a local set of skills and capacities with adequate knowledge to plan, design implement, operate and monitor the project. It is thus important to identify institutions and/or agencies that already have a high level of capacity and skills and those which teach and train such expertise.
- *Financial Arrangements:* Implementing improved waste management services will need start-up funding. Knowing from where investment capital can be mobilized from who and how operational cost can be covered by revenue sources if critical to establishing a sound business plan.
- *Socio-cultural Acceptance:* This part describes the endorsement of the proposed project by the community and their motivation and willingness to participate and contribute to the process and the objective of the solid waste management improvement. Depending on the project this may entail changing mindsets, engrained habits and behaviors as well as financial contribution.

4 Assessment Methods for Decision Support

Currently a large number of methods, approaches and modeling tools have been developed to support decision-making in solid waste management (Finnveden et al., 2007). With the large number of methods available, however it is becoming increasingly difficult for practitioners and decision makers to understand, select and apply the method which is most appropriate for their specific needs (Finnveden et al., 2007; Chang et al., 2011; Pires et al., 2011b). Decision support models or decision support systems (DSS), is the term most frequently used for computerized systems that can be summarized by what Change (2011) calls "system analysis platforms" (Chang et al., 2011). These are approaches that utilize one or more methods of assessment in combination, to develop a more holistic view of the situation or depict the consequence of a suggested alternative. They are all designed to help decision makers apply improvements in solid waste management by providing better knowledge on the situation and the consequences of a particular choice.

Whatever the decision problem, it must be firstly well defined by means of clear objectives that are as specific as possible, smartly measurable, agreed among stakeholders, realistic and time-dependent (DCLG, 2009). Once the objectives are set, steps that follow include establishing a good understanding of the situation, identifying alternate possibilities for achieving the intended objectives, determining and weighting the criteria which shall be used and finally the step in which the solution options are analyzed and choices are made (DCLG, 2009).

Whatever methods are used for assessment, a first step requires defining the scope of the assessment and the respective boundaries of the case or system which will be assessed. The scope relates to the project cycle (Figure 5 in Chapter 3) i.e. if the assessment has the goal to evaluate options for planning and project design purposes or, if it shall assist with the monitoring, evaluation and adaptation process during the operation of a project. Regarding boundaries and the extent of the case to be assessed, most assessment methods are suited for the subsystem level, either to evaluate specific technical alternatives for a subsystem in the overall solid waste management system. Other methods are more encompassing and may also tackle the full system by integrating the individual subsystems to a whole, whereby this task is much more complex and is often used to assess impact of a given choice and not to evaluate alternative options.

In the framework of this thesis the focus will lay predominately on the categories within the "system assessment tools" and on the analysis as to how these tools can contribute and be integrated into "systems analysis platforms" to assist in decision support.

The subsequent sections of this chapter briefly explain the various methods and tools selected, analyzing their strengths and weakness and describing if and how they have been used before in the developing country waste management context. An overview of methods and tools is given in Figure 9.

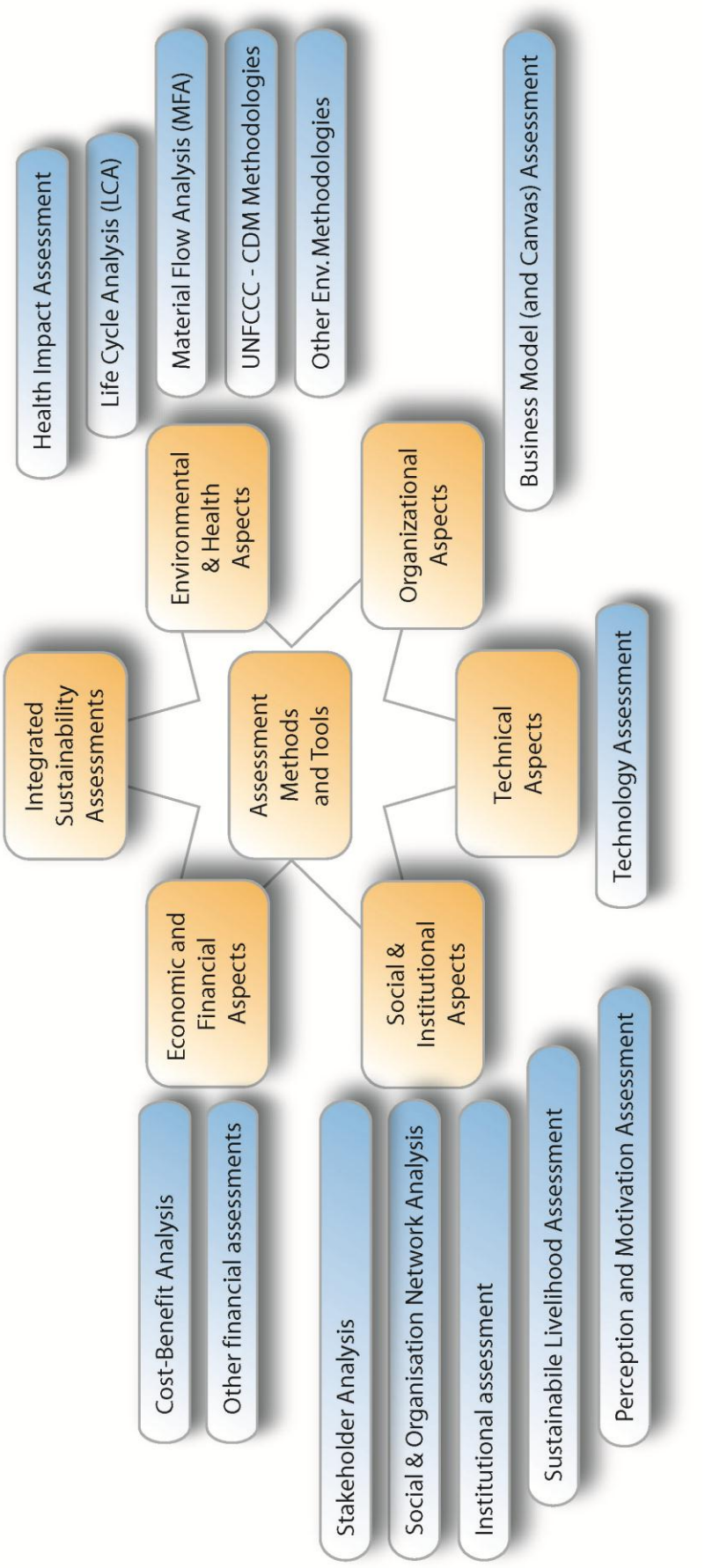


Figure 9 Selected assessment methods and tools ordered by sustainability domain.

4.1 Technical Aspects

Technology assessment refers to "*a scientific, interactive and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology*" (TAMI, 2004). The procedure evaluates possible environmental and societal consequences of new scientific or technological developments. It usually does not have a site-specific perspective but rather starts from the generic technology specifications and evaluates a regional or global impact using other impact assessment techniques like Risk Assessment (RA) or Life Cycle Assessment (LCA) (Van Eijndhoven, 1997). The process of environmental technology assessment is described in UNEP-IETC (undated) as incorporating a four-stage process (abbreviated by DICE) of: (i) Description, (ii) Identification, (iii) Characterization and (iv) Evaluation. The description includes the requirements of the technology and its operating environment then follows with the identification of the pressures the technology places on the environment and the environmental impacts those pressures may cause. Thereafter, the assessment becomes site-specific as the overall consequences of those impacts are evaluated in light of local conditions (UNEP-IETC, undated). This is also reflected in the sustainability assessment of technologies methodology (UNEP-IETC, 2012) whereby additional aspects are included such as: Stability or Resilience; Size/Scale of Operation; Flexibility/Adaptability; Skill Levels needed; and Other Pre-requisites (availability of space, etc.). Some of these aspects are specific to local conditions while others are generic and related only to specifications of the technology.

Another aspect of technical assessment focuses on a more site specific application and view of a specific technology. Technical aspects in solid waste management can thereby relate to the appropriateness expressed in terms of functionality and robustness, either of the technologies that are presently in use or are potential promising future technologies. The "movement" around the concept of appropriate technology started with Schumacher's work and his book "Small is Beautiful: Economics as if People Mattered". Originally he articulated this concept as "intermediate technology", which is generally recognized as encompassing a technological choice and application that is (Hazeltine and Bull, 1999; Akubue, 2000):

- low-cost
- small-scale
- labor-intensive
- energy-efficient
- environmentally sound
- locally controlled and people-centered

Tharakan (2010) further emphasizes the criteria of:

- use of local materials
- affordable
- comprehensible, controllable and maintainable by the users without high levels of education or training (Tharakan, 2010).

Assessing if a technology is "appropriate" can be summarized by evaluating the criteria above or shown in Table 7. The table shows that pure technical issues are not discernible from this list. Instead, all sustainability domains are already represented

and included in this description. The purely technical design and functionality element are embedded in the terms: long life (durability, robustness), small scale local production & reduces transportation dependence (technical expertise for construction and maintenance is locally available), and the aspect of low lifetime costs (affordability).

Table 7 Evaluation criteria of technology "appropriateness", adapted after (Nelson and Yudelson, 1976).

ECOLOGICAL ▪ Does not release pollutants into environment ▪ Protects existing natural habitat ▪ Restores viability of ecosystems ▪ Recycles organic nutrients and creates topsoil ▪ Produces food ▪ Conserves renewable resources	**ENERGETIC** ▪ Conserves non-renewable resources ▪ Promotes use of renewable energy sources ▪ Promotes use of recycled materials ▪ Reduces transportation dependence
ECONOMIC ▪ Long life ▪ Low cost (initial and/or lifetime) ▪ Promotes small-scale production, local ownership, bio-regional production ▪ Promotes "right livelihood" (meaningful work, income) ▪ Labor intensive	**SOCIAL/POLITICAL/CULTURAL** ▪ Provides human habitat ▪ Promotes social flexibility and adaptability ▪ Promotes self-reliance and community cooperation ▪ Understandable/usable at community level ▪ Creates/maintains natural beauty

AKVO, a knowledge hub on water and sanitation issues, has developed an appropriate technology checklist to help determine the sustainability of a technology regarding technical, social, financial and logistical aspects. (AKVO, 2012). When extracting only the pure technical issues the criteria can be summarized as follows:

- Repairability: This concerns the question if the technology can be repaired easily by the user after it breaks down. If it cannot be not be, then the question arises if there is an existing supply chain and infrastructure that can do that at an affordable cost.
- Self-maintenance: Can users maintain the technology? If not, is there an existing supply chain and infrastructure that can do that at an affordable cost?
- Skills: Does introducing the technology include appropriate training on operation and maintenance by local users?
- Locally grounded: This considers if the technology can be built by the local private sector with locally available materials and skills.
- Robustness: Maintenance and repairs are unavoidable, but critical is the questions if the frequency of such tasks is acceptable to the user.
- Replicability: Can the technology be replicated and scaled-up to make a significant impact on the wider environment?

Bhamidimarri and Shilton (1996) as well as Baetz and Korol (1995) apply and discuss technology criteria with specific reference to solid waste issues. Bhamidimarri (1996) cites Jequier and Blanc (1983) on the characteristics of appropriate technology as: (1)

low investment cost per unit of output; (2) organizational simplicity; (3) high adaptability; and (4) sparing use of natural resources. However at the same he argues that appropriate technology suffers from the image of low-tech and as such, the understanding of such technology is directed towards the poor and developing countries although the technolgy's application is very well suited also for developed countries (Bhamidimarri and Shilton, 1996). Zelenika and Pearce (2011) agree and elaborate on this aspect as one significant barrier to fostering widespread implementation. In their view the notion of appropriate technologies holds back on modernization and infringes on competitiveness as it undermines the demand of developing regions for the same or similar technologies as in developed regions (Zelenika and Pearce, 2011). Baetz and Korol (1995) argue that technology development by engineers needs to go beyond the functionality and cost-effectiveness criteria and technology needs an evaluation through a sustainability perspective. They suggest seven criteria: (1) integration (within ecosystems); (2) simplicity; (3) resource inputs required; (4) functionality; (5) adaptability; (6) diversity; and (7) observing environmental carrying capacity (Baetz and Korol, 1995).

Technical functionality depends on the site specific physical conditions and the technical infrastructure (hardware), the available know-how and skill to operate the technology and the organization and management related factors (Madu, 2005). However also acceptance and perception of the users of technology influence successful and long term performance. An example in sanitation shows how a combination of technical performance according to specifications and technical performance according to perceptions of the users can be assessed (Roma and Jeffrey, 2011). This feedback loop from the users is rooted in the framework of receptivity, defined as: the willingness and ability/capability of users to absorb, accept and utilise the technology option. These two elements of the assessment are visualized in Figure 10.

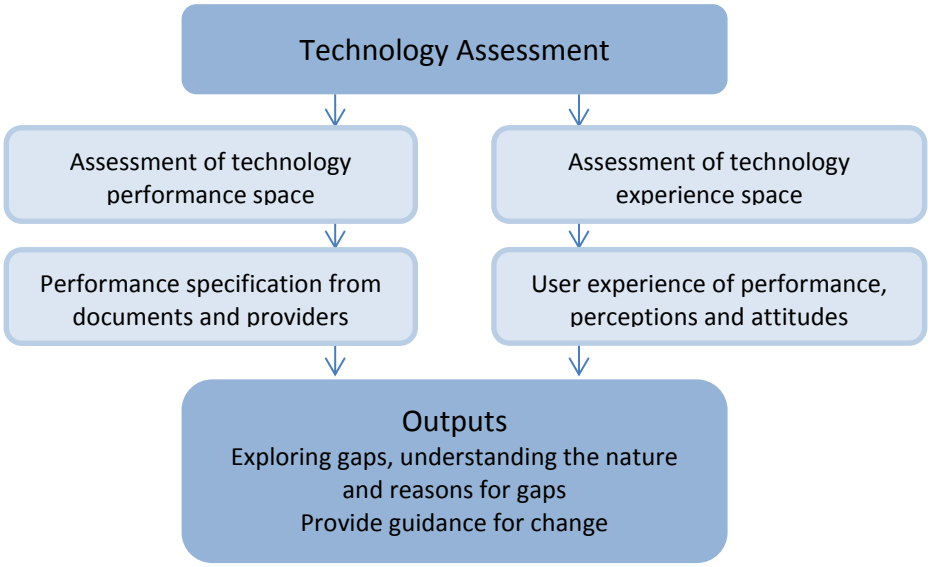


Figure 10 Combining assessment of technical performance by specification and technical performance by perception, adapted after (Roma and Jeffrey, 2011)

Another example of including the users and local stakeholders into the assessment is from the ongoing work in the EU-FP7 project "WASHTech" which is developing a

technical assessment framework (WASHTech Consortium, 2012). The envisaged approach considers 18 indicators, which are developed based on 6 sustainability dimensions (technical, economic, social, environmental, institutional/legal, skills/knowhow) and three particular stakeholders' perspectives (user/buyer, producer/provider, regulator/investor/facilitator/supervisor). The indicators and respective questionnaires are currently being tested in field sites (Olschewski, 2012).

A review of academic literature regarding technical assessments of solid waste management in developing countries, reveals a large amount of published studies related to specific geographic locations, with the goal to identify appropriate upgrading of technical elements such as: collection vehicles (Collivignarelli and Vaccari, 2007; Collivignarelli et al., 2010; Di Bella, 2010; Ali, 1996), intermediate storage containers (Bleck and Wettberg, 2012), hospital waste treatment (Blenkharn, 2006; Di Bella, 2010; Di Bella et al., 2012), organic waste treatment technologies (Ali, 2004; Alavi Moghadam et al., 2009; Alter Ego, 1996; Karagiannidis et al., 2009; Zurbrügg et al., 2007b; Zurbrügg, 2005; Zurbrügg et al., 2005; Zurbrügg et al., 2004) industrial waste treatment (El-Fadel et al., 2001), e-waste treatment (Osibanjo, 2007; Wang et al., 2012a), or landfill disposal (Alam et al., 2007). Only few publications however systematically check how the suggested technology improvements would conform to the criteria established for appropriate technologies. Cost, energy requirements, skills for operation and maintenance are aspects frequently considered beside other non-technical issues such as environmental emissions.

A checklist of critical questions for assessing technologies can be summarized:

- Is the technology designed to operate under the local physical (e.g. climate, topography) and/or infrastructure conditions (e.g. roads, power supply)?
- Can the system easily cope with and adapt to changing conditions/contexts?
- Is there sufficient local availability of material resources (supply chain, material and spare parts) for construction, operation and maintenance of the technology?
- Is there appropriate local know-how and experience (skills) available to design and build the technology?
- Is there sufficient know-how and experience (skills) locally available to operate and maintain the technology?

New and innovative technologies will not comply well with the "soft factor" (skills, experience) requirements. Understanding the risks of innovation can be a trigger for respective mitigation activities such as a close collaboration with research centers, demonstration-scale pilot technologies, development of training courses, adaptations in university curricula, invitation of foreign experts, etc. (ISSOWAMA, 2011a).

4.2 Environmental and Health Aspects

Besides the objective to protect public health, a second main purpose of solid waste management is the conservation of the (global) resource base and the protection of environment. Achievement of these environmental goals is measured through resource and environmental sustainability. The method of life cycle assessment used for environmental impact and the method of health risk to describe threats to humans

are described as the two most frequently used tools in solid waste research of the last 15-year period (Yang et al., 2012).

4.2.1 Health Impact Assessment

How to conduct health impact assessments (HIA) is well documented and supported by the publication of the International Finance Corporation (IFC) published in 2009: "Introduction to health impact assessment". Two key characteristics define health impact assessments: (1) predicting the consequences of project-related actions, and (2) providing information that can help decision makers develop and prioritize mitigation strategies throughout the project cycle. The stages of a health impact assessment process can be summarized in IFC (2009) as follows:

- *Screening:* involves a first assessment to screen whether the specific intervention is likely to result in any significant health risks.
- *Scoping:* involves a process to outline the types of hazards as well as beneficial impacts, in participatory manner with local stakeholders.
- *Risk Assessment:* encompasses various activities to map, analyze and qualitatively/quantitatively rank the different health risk impacts the project is likely to have on the health of the defined communities.
- *Health Action Plan:* takes into account the rankings developed in the previous step and thereby extracts a health action plan which suggests actions to mitigate the expected health impacts.
- *Implementation and Monitoring:* here decisions are taken about how the mitigation activities will be implemented and monitored and roles and responsibilities are assigned to key stakeholders. The monitoring system should be designed to also capture unanticipated effects.

Health impact assessment is a critical tool for developing evidence-based recommendations for project decision makers and key stakeholders (Winkler et al., 2011; IFC, 2009). In the context of solid waste management projects, health risk studies are documented in literature with a focus on studies regarding effects of waste landfills and incinerators on the health of nearby residents. Giusti (2009) provides a literature review on the different waste management practices and their respective impact on human health. The author took into account work on health risks of population living near landfill sites, incinerators, composting facilities and nuclear installations and comes to the conclusion that the evidence of adverse health outcomes is usually insufficient and inconclusive (Giusti, 2009). Most research studies identified are dedicated to developed country situations (USA and Europe) (Buonanno et al., 2011, Cordier et al., 2010; Davoli et al., 2010; Gerba et al., 2011; Heaney et al., 2011; Lonati and Zanoni, 2012; Musmeci et al., 2010; Vilavert et al., 2012), with only few from low- and middle-income countries (El-Sayrafi et al., 2011; Forbid et al., 2011; Minh et al., 2003). Also, results are reported from e-waste recycling (especially relevant in low- and middle-income countries) (Arun Vasantha Geethan et al., 2012; Wang et al., 2012b; Chen et al., 2011; Frazzoli et al., 2010; Tsydenova and Bengtsson, 2011; Wath et al., 2010), health care waste management (Malarvannan et al., 2009; McDiarmid, 2006; Patwary et al., 2011; Haylamicheal et al., 2011), bio-aerosol risks from composting or sorting facilities (Fracchia et al., 2006; Lake, 2002; Persoons et al.,

2010; Schlosser et al., 2009; Sykes et al., 2007; Taha et al., 2007; Malta-Vacas et al., 2012) and overall risks for waste workers or recyclers (Bleck and Wettberg, 2012; Bunn et al., 2011; Harpet, 2003).

In summary: health impact assessment is a very valuable tool which is well defined and documented. It is increasingly becoming a routine feature of the project permitting and approval process. Nevertheless, methodologies for HIA have been developed, validated and applied in Western Europe and there is a need to adapt methodologies for developing country settings where the baseline health data is lacking (Winkler et al., 2011).

4.2.2 Life Cycle & Environmental Impact Assessment

Of the wide range of methods for environmental assessment, Finnveden (2007) distinguishes between procedural and analytical methods (Finnveden et al., 2007). Procedural methods relate to a societal and decision making context whereas analytical methods focus more on the technical aspects of the analysis (Wrisberg et al 2002, cited in (Finnveden et al., 2007)). Environmental Impact Assessment (EIA) or Strategic Environmental Assessment (SEA) are good examples of procedural methods. The techniques used in EIA and SEA are analytical methods such as life Cycle Assessment (LCA) as part of the procedural process.

The most frequently used analytical assessment approach is life-cycle assessment (LCA), also called life-cycle analysis, or cradle-to-grave analysis (US Environmental Protection Agency, 2012). Life Cycle Assessment (LCA) is a method to assess the environmental performance of products or services over their whole life cycle including resource consumption, production, utilization and finally the disposal aspects. The procedure of conducting a LCA is well defined and described by the Standard ISO 14040 (ISO 14044, 2006). The design of a LCA contains four main steps (Figure 11) whereby the individual steps are in succession but should also allow an interactive process (Rebitzer et al., 2004; Pennington et al., 2004).

i. Definition of goal and scope
ii. Inventory
iii. Impact Analysis
iv. Interpretation

The assessment is defined by goal and scope; "functional unit" – in solid waste management usually expressed in mass (kg or tons) of waste handled - and system boundaries (geographical and temporal). Here interest and target audience for the results must be clarified. This is particularly important when LCA is conducted for different comparable options (Volkart, 2011). The environmental aspects and potential impacts associated with a product, process, or service are evaluated by:

- Compiling an inventory of material inputs, energy consumption and environmental emissions
- Evaluating the potential environmental impacts linked to the identified inputs and emissions
- Interpreting the results to sustain a more informed decision

Common impact categories used in LCA are: global warming, stratospheric ozone depletion, photochemical ozone formation (smog), acidification, eutrophication, as well as human and ecotoxicity (ISSOWAMA, 2011a). Depending on the impact categories of interest respective methods for attributions and characterization are recommended (EU-JEC, 2011).

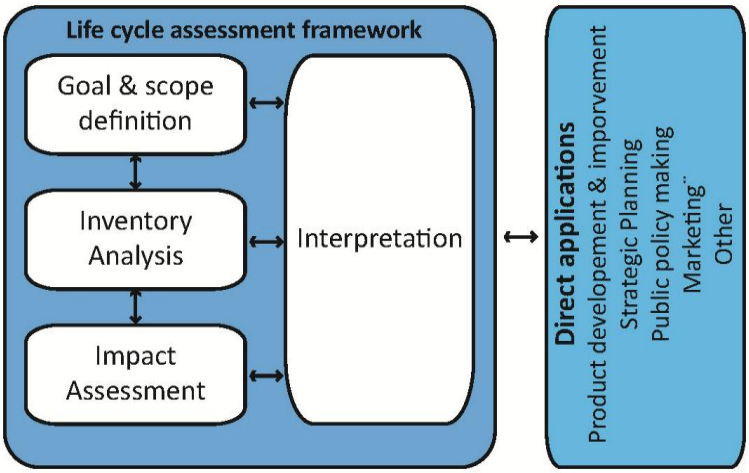


Figure 11 The general methodological framework for LCA. The element of "impact assessment" is frequently also called LCIA (ISO 14044, 2006).

Among the large amounts of software tools available to assist with conducting an LCA, SimaPro software is frequently applied which supports the user by providing a direct link to inventory databases and the most common impacts characterization methods.

In waste management, LCA methods are being integrated into models as decision support tools. One example is EASEWASTE/EASETECH (Environmental Assessment of Solid Waste Systems and Technologies), a computerized LCA-based tool for modelling integrated waste management syste (Christensen et al., 2007). According to Christensen (2007) EASEWASTE "provides a versatile system modelling facility combined with a complete life-cycle impact assessment and in addition to the traditional impact categories addresses toxicity-related categories. New categories dealing with stored ecotoxicity and spoiled groundwater resources have been introduced". EASEWASTE has also been applied in low- and middle-income countries, for example in China (Zhao et al., 2009). Gentil (2010) provides an overview of the available different models and provides a word of caution as large discrepancies have been observed among different waste LCA models regarding the results. The aspects which have significant impacts on the results are listed as: the functional unit, system boundaries, waste composition and the energy modelling approach. Gentil's review concludes that more effort should be undertaken to harmonise and validate non-geographic assumptions used in the models (Gentil et al., 2010).

In order to compile the inventory, good knowledge of the system to be analysed is necessary. This is a challenge when a range of potential future options shall be evaluated (Vervaeke, 2012). In a LCA study for organic waste treatment options in

Bolivia, for instance, inventories on transport, infrastructure, operation and use were completed using information on material, energy flows and specific emissions from international literature (Volkart, 2011). Default values were further used as suggested in the IPCC Guidelines for National Greenhouse Gas Inventories and information provided through the "Ecoinvent Database" containing life cycle inventory data on energy supply, resource extraction, material supply, chemicals, metals, agriculture, waste management services, and transport services (www.ecoinvent.ch). Most of this information contained in the database however derives from studies in Europe and North American and little is available which relates directly to low- and middle-income countries.

When looking at past research and the application of LCA to solid waste management elements in developing countries, one can observe a range of studies by researchers doing comparative analysis of different waste treatment options (Aye and Widjaya, 2006; Bhander et al., 2008; Bohra et al., 2012; Qu et al., 2012; Batool and Chuadhry, 2009). Fewer studies in developing countries use LCA for analysis of the whole waste management system (Özeler et al., 2006; Othman et al., 2012). Practical applications of LCA are usually more directed to one certain industrial production process to analyze emissions and devise mitigation options. An example is from tanning industries, which in developing countries traditionally uses chromium in the tanning process (Rivela et al., 2004) and thus contribute highly toxic emissions into the environment if not treated properly.

A critical view of LCA and its practical use and application for developing countries is summarized in the UNEP (2005) publication "Life Cycle Approaches: The road from analysis to practice" (UNEP, 2005b). Herein it is mentioned that data sources must be further developed to also include environmental issues relevant for developing countries. Furthermore a boarder social and economic dimensions of sustainability is recommended. The analytical approaches, as usually developed by academia, are highlighted as too complicated, and not sufficiently made for easy use. Such complicated tools may well be useful for large companies or national governmental organizations and research centers, but they are difficult to apply by local governments, small and medium enterprises or even more by local stakeholders in developing countries (UNEP, 2005b). The main barriers are:

- the lack of appropriate data (for inventory data specific to developing country conditions)
- the lack of LCA expertise/know how
- the lack of funding for LCA
- the absence of perceived needs

The limitations of focusing only on environmental aspects have in recent years been taken into consideration and life cycle (environmental) assessment is now one tool among a portfolio of other tools, such as risk assessment, life cycle costing, value chain, and social analysis (Guinée et al., 2010; Sala et al., 2012).

4.2.3 Material Flow Assessment

Material flow analysis (MFA) is a method which is rooted in system analysis. It uses a system description with processes, transformation functions, flows and stocks of materials or substances. In developed countries, MFA has proven to be a suitable method and tool for the early recognition of environmental problems and the development of mitigation measures (Baccini and Brunner, 1991) (Montangero, 2005). As the system inflows, outflows and stocks conform with law of the conservation of matter, the results of an MFA can be controlled by a simple material balance (Brunner and Rechberger, 2004). MFA can be applied to analyze flows of resources in a city or region and changes in consumption patterns, solid waste and/or wastewater treatment infrastructure, waste and wastewater reuse practices, peri-urban agricultural production, and environmental pollution.

In the developing country context focused on solid waste, MFA was applied in the city of Kumasi (Ghana) to assess how much of the nitrogen and phosphorus demand in urban and peri-urban agriculture could be covered by compost produced from urban solid waste and excreta (Leitzinger, 2000; Belevi, 2000; Belevi, 2002). In a Vietnamese rural area MFA was useful for describing sanitation, agricultural and waste management practices and future forecasts of surface water pollution under certain mitigation scenarios. (Do-Thu et al., 2011). Meinzinger (2009) applied MFA as a tool for sustainable sanitation planning in Ethiopia. One scenario included a co-composting site which co-treats municipal organic waste together with faecal sludge from pit latrines and septic tanks. The resulting compost is then used in agriculture (Meinzinger et al., 2009). Yiougo (2011) did the same for the town of Pouytenga in Burkina Faso (Yiougo et al., 2011). In the Caribbean, material flow analysis (MFA) was used to assess amounts of tire waste to judge if a treatment facility could be justified (Sarkar et al., 2011). In China, dynamic MFA was used for strategic planning of the construction and demolition waste system (Hu et al., 2010) and in Taiwan heavy metal emissions from incineration plants in fly ash and slag were assessed using MFA (Kuo et al., 2007; Lu et al., 2006). In South Africa, the City of Cape Town drafted an energy strategy and an integrated waste management plan with the help of MFA, focusing on wood and paper waste (Nissing and Von Blottnitz, 2007). Material flow analysis was also applied to Kayangel Island in the Republic of Palau. Here household solid waste and marine litter was quantified and characterized including the spatial dimension of non-putrescible materials that become solid waste (Owens et al., 2011). MFA can easily be combined with other assessment and evaluation methods. One example is its use together with process cost accounting in a study to evaluate options of decentralized versus centralized composting for the city of Asmara, Eritrea (Zurbrügg et al., 2006).

MFA is considered a helpful tool which, however, in developing countries suffers from limited data availability, reliability or means for data collection (e.g. laboratory equipment, trained staff, or financial resources). These factors challenge the use of MFA as a policy-making tool. Nonetheless, new developments in using literature values combined with expert judgment to establish probability distributions for model parameters looks promising and would help to overcome this barrier (Montangero, 2005).

4.2.4 Clean Development Mechanism (CDM) Methods

In 1992, following the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, the United Nation Framework Convention on Climate Change (UNFCCC) was established to develop ways to limit the increase in global temperature and the impact on climate change. Thereafter, in 1997, the Kyoto Protocol was established. It has the overall goals to reduce greenhouse gas emissions worldwide. Countries that ratified this international protocol are legally bound to reduce their greenhouse gas emissions by 5.2% relative to the year 1990 (UNFCCC, 2011).To assist countries in achieving this, the Kyoto Protocol introduced three market-based mechanisms: (1) International Emission Trading (IET), (2) Joint Implementation (JI) and (3) Clean Development Mechanism (CDM) (UNFCCC, 2010). With the Clean Development Mechanism the Kyoto Protocol allows developing countries to implement emission reduction projects and obtain support for this by registering these carbon reduction emissions, which can then be traded on the international market as Certified Emission Reductions (CERs) (Plöchl et al., 2008). Each CER is the equivalent to one ton of CO_2 (UNFCCC, 2010).

Table 8 CDM methodologies for solid waste project.

Description	Number**
Avoided emissions from biomass wastes through use as feed stock in pulp and paper, cardboard, fibreboard or bio-oil production	AM0057
Avoidance of landfill gas emissions by in-situ aeration of landfills	AM0083
Avoidance of landfill gas emissions by passive aeration of landfills	AM0093
Flaring or use of landfill gas	ACM0001
Alternative waste treatment processes[+]	ACM0022
Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/ thermal treatment	AMS-III.E.
Avoidance of methane emissions through composting	AMS-III.F.
Landfill methane recovery	AMS-III.G.
Avoidance of methane emissions through excavating and composting of partially decayed municipal solid waste (MSW)	AMS-III.AF.
Recovery and recycling of materials from solid wastes	AMS-III.AJ.
Methane recovery through controlled anaerobic digestion	AMS-III.AO.
Methane oxidation layer (MOL) for solid waste disposal sites	AMS-III.AX.
Recovery and recycling of materials from E-waste	AMS-III.BA.

** AM and ACM numbering indicates methodologies for large scale CDM project activities; and AMS small scale CDM project activities

[+] Involves one or a combination of the following waste treatment options: Composting process in aerobic conditions; Gasification to produce syngas and its use; Anaerobic digestion with biogas collection and flaring and/or its use (this includes processing and upgrading biogas and then distribution of it via a natural gas distribution grid); Mechanical/thermal treatment process to produce refuse-derived fuel (RDF)/stabilized biomass (SB) and its use; Incineration of fresh waste for energy generation, electricity and/or heat; Treatment of wastewater in combination with solid waste, by co-composting or in an anaerobic digester.

Before validation, all project proposals submitted for CDM registration, must pass through a rigorous and public evaluation. The project must take reference to a baseline situation where CO_2 equivalent (CO_2e) emissions are estimated that would occur without the project. Then, the emissions savings by the project are calculated using standardized and approved methodologies (UNFCCC, 2012a). Calculations of CERs are done for a defined crediting period (7 or 10 years) in which the project is operated, monitored and the credits verified. The main methodologies used for assessing CO_2e emissions and emission reductions are established for the solid waste sector (Table 8). Most methodologies are set to evaluate reduction of anaerobic decomposition of organic waste and production or venting of methane into the atmosphere, as one ton of methane is equivalent to 21 tons of CO_2. However, also projects which increasing recycling activities (in general or specific to e-waste) are eligible for CERs (UNFCCC, 2012a).

Currently in the category of projects on "waste handling and disposal" registered with CDM-UNFCCC (cdm.unfccc.int) 209 concern projects on landfill gas capturing and 53 on composting. Next to CDM there is another very similar mechanism, not formally attached to CDM, called the Gold Standard. This comprises a certification standard for carbon mitigation projects and was established in 2003 by the World Wide Fund for Nature (WWF) (www.cdmgoldstandard.org). The Gold Standard uses the methodologies of UNFCCC, however is less complex with regard to the registration, evaluation and verification process.

Research regarding CDM methodologies for emission assessment in the solid waste sector focuses predominantly on either, comparing results from using CDM methodologies with other methods (Volkart, 2011), or use of the methods to estimate local or regional emissions (Couth and Trois, 2010, 2012; Friedrich and Trois, 2010; Abushammala et al., 2011) and emission reduction potential by alternative waste treatment options (Barton et al., 2008; Couth and Trois, in press; Friedrich and Trois, 2011; Unnikrishnan and Singh, 2010; Garcilasso et al., 2011; Abi-Esber and El-Fadel, 2012; Tayyeba et al., 2011). Fewer studies look into more detail of the waste treatment process and verify through evidence if the parameters used in the CDM methods are justified (Raninger et al., 2008; Ramnauth et al., 2012; Bogner et al., 2008). Stucki (2006) for instance analyzed methane emissions from windrows under different operating procedures (Stucki, 2006).

4.2.5 Other Environmental Assessment Methods

Footprint methods are rapidly developing and gaining more visibility. For instance the water footprint is an indicator of water use - both direct and indirect - of a consumer, producer, product or service. The water footprint is defined as the total volume of freshwater that is used to produce goods and services of concern (www.waterfootprint.org). In solid waste management services or treatment facilities this may be an exciting exercise to conduct. The use of (fresh) water for composting in arid climates with high evaporation rates would probably give a good indication of the relative low feasibility considering the cost and scarcity of water in those regions.

Other solid waste process most probably will not have a large water footprint, besides using freshwater to clean vehicles or spray landfill access roads to avoid dust.

Ecological footprint analysis on the other hand compares human demands and nature's capacity to regenerate resources and provide eco-services. This is done by assessing the land and marine area required to produce the resources and absorb the waste. Only few research studies were identified that used the method of ecological footprint for assessment in solid waste management. In Bangladesh this was used to assess the land required to assimilate the waste generated by the population of Khulna (Salequzzaman et al., 2006). In a similar fashion, it was used in China for the cities of Beijing and Shenyang. (Feng et al., 2011; Li et al., 2012), whereas in Spain it was used in combination with multi-criteria analysis for evaluating municipal solid waste treatment alternatives

Emergy Analysis: Emergy is a form to express energy consumption using an energy hierarchy. "*Many joules of sunlight are required to make a joule of fuel, several joules of fuel to make a joule of electric power, many joules of electric power to support [a certain service], and so forth*" (Odum et al., 2000). Expressing each type of energy consumption in one comparable form of energy quantity is emergy (spelled with an "m"). The unit of emergy is the emjoule. Sunlight, fuel, electricity are expressed as emjoules of solar energy (abbreviated sej) (Odum et al., 2000). Emergy analysis has not yet been frequently used in solid waste assessments, and even less so in a developing country context. In Italy emergy analysis was used by Marchettini et al (2007) to compare waste management options and strategies (Marchettini et al., 2007). Composting was assessed as a possible management option and the emergy analysis showed that the highest investment (calculated in emergy units) results during collection of source segregated organics. In comparison the emergy cost of plant operation, is significantly lower (Bastianoni et al., 2002). Lei (2008) adopted the emergy analysis method to evaluate the sustainability of Macao's support systems, food production, tourism and waste treatment processes (Lei et al., 2008).

In summary the following quite generic questions to consider for a simple environmental assessment could be:

- Are health impacts by the project on workers, neighbors or downstream population expected and monitored, and what mitigation measures are proposed and implemented?
- Do the project emissions (forecasted or current) on water, soil and air fulfill the environmental legislation of the country?
- Which are the critical points in operation which must be ensured to avoid major pollutant emissions into the environment, and how are points monitored and supervised to avoid failure?
- Are procedures in place to mitigate the damage in case pollutants are emitted to the environment?
- What are major resource consumption sectors (water, energy, etc.) and are provisions taken to minimize these?
- What are CO_2e emissions of the project and are measures taken to reduce these?

4.3 Economic and Financial Aspects

Economic impacts are the effects of any project on the level of economic activity in a given area. A positive economic impact can be: (1) business sales, (2) value added for customers (3) wealth increase in the area (e.g. property values), (4) staff income or employment opportunities. Any of these can be an indicator of improvement in the economic well-being of area. Unfortunately, municipal solid-waste management in developing cities is often a considerable burden on municipal and household budgets. Also for industries, the costs of getting rid of their waste can be high. On the other hand, recycling and reuse of wastes can offer many important opportunities to the poor fraction of the population and for the development of small and medium enterprises (SME). Such revenues and employment opportunities can have an important positive effect on the local economy (Scheinberg, 2001a, b). However, for other recyclables for which there is limited demand, there may be higher costs of producing the recycled product than the financial benefits of those products. Here, the benefits are often more indirect and companies that work in this sector often need some form of governmental support (ISSOWAMA, 2011a). Given the constrained financial situation in developing countries there is an urgent need for improved financial assessment methods for solid waste management.

4.3.1 Cost-Benefit Analysis

The assessment method of cost-benefit analysis (CBA), sometimes also called benefit–cost analysis (BCA), is a systematic process for calculating and comparing benefits and costs of a project. The approach has the goal to (a) justify the decision to invest, and (b) to compare projects. Benefits and costs are calculated in monetary terms. To account for the time value of money, all money flows are expressed on a common basis in "net present value" (Cellini and Kee, 2010). Such an analysis can be performed when a project is being considered (prospective analysis), during operation of the project (a snapshot in time) or after the project end as a way of evaluating performance (retrospective analysis)

CBA is closely related to cost-effectiveness analysis with the difference that cost effectiveness is more straightforward and simpler. Cost-effectiveness analysis relates the costs to a specific measures of effectiveness (Cellini and Kee, 2010). In solid waste management this “unit of effectiveness” is typically a defined mass of waste managed/treated. Thus, cost-effectiveness is the ratio of costs and the unit of effectiveness, for instance US$/ton of waste treated. In comparison cost-benefit analysis goes further by evaluating the value, in monetary terms, of the benefits. Benefits are defined as an increase in human well-being and costs are reductions in human well-being (Chang et al., 2011). The “net-benefit” is the difference between benefit and cost. All impacts (financial, economic, social, environmental) should be assessed and put into monetary terms. When comparing between options, only the difference between the baseline and the various scenarios are assessed. This is called the marginal or incremental approach (EU Authority for the Coordination of Structural Instruments, 2009).

The 10 steps for conducting a CBA are as follows (Cellini and Kee, 2010):

1. Set the framework for the analysis (is a CBA needed?)
2. Whose costs and benefits should be included (setting the boundaries of analysis)
3. Identify and categorize costs and benefits
4. Establish costs and benefits for the life of the project (future)
5. Monetize all costs
6. Monetize all benefits
7. Discount costs and benefits in the future to obtain present values
8. Compute net present value
9. Perform sensitivity analysis
10. Make a recommendation where appropriate

4.3.2 Other Economic and Financial Assessments

Next to CBA there are other approaches for economic and financial assessment which are becoming prominent in research and practice. These are Full Cost Accounting and Life Cycle Cost Approach. Furthermore, this chapter also briefly describes the method of Net Present Value, a key financial tool for calculating financial feasibility of a project.

Life-cycle costs refer to the costs of ensuring the delivery of services not just for a few years, but indefinitely (through the life cycle).For water and sanitation services the life-cycle costs approach (LCCA) was developed to provide a framework of analysis for cost data in developing countries. A breakdown of cost components is similar to the traditional cost accounting methods, however this approach also takes the “source of expenditure” into account (Fonseca et al., 2011). Once the cost data is assembled, Fonseca et al. (2011) describes the various analysis processes as follows:

- Establishing cost components: capital expenditure, operational expenditure, capital maintenance expenditure, cost of capital, etc.
- Differentiating the costs by the source of expenditure: household, local government, central administration, service provider, etc.
- Listing costs by each infrastructure component
- Establishing costs by the volume or mass of specific service or goods provided (water or waste)
- Calculating cost in relation to people served: cost per person/ household/ poor community/ village/ population density
- Defining costs by variations in service level: services accessed and used for a specific defined quantity, quality standard, hours of service
- Differentiating costs by variable service delivery models: combination of technologies and institutions providing a specific service in one area

Full cost accounting: Similarly to life cycle costing, the full cost accounting is also a systematic approach that helps identify actual costs beyond only infrastructure of solid waste management (EPA, 1997). This approach accounts for past and future investments, the management and overhead costs (e.g. support services) and operating costs. The US Environmental Protection Agency promotes this approach to help municipalities understand and be able to better communicate the cost of waste

management to citizens and to also develop and justify tariff structures, or "unit-based pricing" (i.e. pay-as-you-throw) programs (EPA, 1997). For the Philippines, a specific guidebook on full cost accounting was developed to guide municipalities through the various steps of calculating and reporting full costs. 10 Steps are identified herein with examples (DENR-USAID and EcoGov, 2004), whereby specific attention is given to depreciation costs and costs of capital, often two neglected aspects in solid waste accounting. Also, for Latin America, this approach was strongly promoted and the Pan-American Health Organization (PAHO) developed a specific software tool for solid waste management – COSEPRE. This shall assist municipalities pursue a approach to better know their costs and to identify those parts of the system that are consuming excessive resources and then take corrective action (PAHO and CEPIS, 2001).

Net Present Value: This calculates the net financial benefit for every year of the project (present and future) (equation 1). As future benefits are worth less than present ones, NPV discounts the money in the future to the value of the present. The difference between the present value of the future cash flows and the investment is the Net Present Value. If the NPV is positive then it means a better return on investment (Jewell, 2000).

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o$$

Equation 1

C_o : Initial investment
C_t: Net value (revenue minus cost) in year t
t: year, whereby T is the last year and the first year is t_1
r: discount rate

Analyzing solid waste research literature shows that the term cost-benefit is often misused, and most often it is a simple cost evaluation or cost-effectiveness analysis and the valuation of benefits in monetary terms is rather neglected. Already back in the 70s, for waste management, systems engineering models started using linear programming with a single cost minimization/optimization scheme. With time the models became more sophisticated to not only optimize for cost but also other objectives, which induced the start of multi-criteria decision models (MCDM) (Chang et al., 2011). In Myanmar, Tin (1995) used economic costing to find least-cost alternative systems for improvements to the collection system. In Indonesia economic assessments compared the options available for traditional market waste disposal, composting in labor-intensive plants, composting in a centralized plant, a centralized biogas production facility and a landfill for electricity production (Aye and Widjaya, 2006). In Thailand, the method of cost-benefit analysis was applied to a variety of options for use of market waste. The results show that processing organic waste in a biogas reactor biogas is most advantageous both environmentally as well as financially. Using this option the cost-benefit ratio is three times higher after conversion, as compared to before (Ali et al., 2012). In Eritrea an economic valuation compared three different scenarios of composting (decentralized, semi-centralized and centralized at the landfill) using process cost accounting and material flow analysis (Rothenberger,

2007; Zurbrügg et al., 2006) showing not only total cost but attributions to cost types (Figure 12).

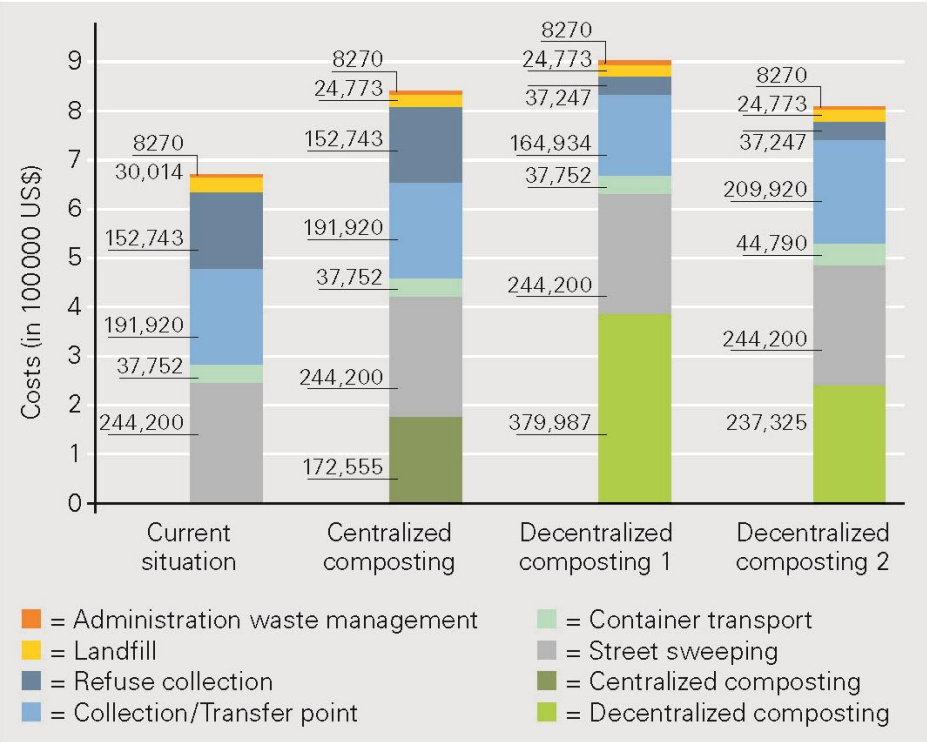


Figure 12 Cost analysis by process step, applied to the existing waste management system in Asmara, Eritrea, and for three alternative scenarios of composting (source: (Rothenberger, 2007)).

The use of CBA or at least Cost-Effectiveness Analysis (CEA) to aid in decision making for solid waste management is considered essential in any instance (Chang et al., 2011), whatever other method, model or simulation is used. Municipalities must be able to clearly identify how much they are spending for what. Only by systematically collecting and analyzing such data can inefficiencies be identified and rectified. Also they must clarify the amount and sources of revenues and how these could be improved. For India, Appasamy (2007) describes the typical public funding streams for waste management (Appasamy and Nelliyat, 2007) whereby sources for capital investments (CAPEX) or operational expenditures (OPEX) will differ:

- Local taxes such as the property tax (OPEX)
- User tariffs which are charged for various urban services (OPEX)
- Grants from higher levels of government (Central, State Governments) (CAPEX or OPEX)
- Capital market loans obtained from government/financial institutions or international lending agencies as the World Bank (CAPEX).

The city of Ho Chi Minh for instance faced major revenue gaps. In 2008 the city government introduced a new tariff system with an increase of collection fees for small shops and households on main streets. This new system however met with solid

public resistance and yet no data are available on the amount of the recovered costs (ISSOWAMA, 2011a).

In summary CBA is most useful when analyzing a single project and its total costs and benefits to society or when comparing alternative programs to see which one achieves the greatest benefit to society. The major difficulty with CBA is that it is often difficult to place monetary terms on many costs and benefits. This issue of monetizing benefits, not double counting benefits, etc. is by itself a field of complex and intricate research, most waste management specialists can only tackle with assistance by experts of that specific disciplinary field. Cost-effectiveness analysis however, is useful when the project outcome is already determined and the goal is to find the least cost option for that outcome. Cost-effectiveness analysis is also useful when major outcomes are difficult to monetize (Cellini and Kee, 2010).

In an economic assessment of a solid-waste management system under study the key questions to consider are(ISSOWAMA, 2011a):

- What are the costs and revenues, structured by cost types?
- Is the system handling waste in the most cost-efficient way possible?
- Are operational expenditures sufficiently recovered by revenues?
- Can and are investment costs depreciated annually?
- Is cost recovery of the waste handling system sustainable in the long term?
- Does a NPV calculation result positively?

4.4 Social and Institutional Aspects

Solid waste management is not something that can be solved only by smart innovative, technology or engineering. As a dominant urban issue, it relates closely to people through waste generation and is linked to lifestyles and resource consumption patterns. As people are the source of waste, socio-economic and cultural issues are important aspects to tackle. The interaction among people their participation and empowerment are critical in all phases of a solid waste project. Furthermore social acceptance, affordability and willingness to pay are additional aspects that have to be established and coordination using a common platform in order to ensure a long-term solution for sustainable solid waste management. A socially enabling environment that affects a project and on the other hand the impact of the project on the socio-economic and cultural situation are two interrelated aspects within solid waste management projects. The social enabling (or disabling) environment can be assessed by social assessment, whereas measuring impact of a project is captured by a social impact assessment (U.S. Department of Commerce, 1994).

Social endorsement of any proposed project by the residents and community will necessitate their interest, motivation and willingness to participate and contribute to the process and the objectives of the project (Lüthi et al., 2011). This may include changing behavior and mindsets or also financial contributions.

On the other hand, every solid waste management project will have an effect and impact on the socio-cultural environment. Social impact criteria may include: equity

(distribution of impact on different social groups), participation/collaboration, gender equity, employment, relationships, acceptance, motivation, interest, and influence (power).

A first and critical step in any social assessment is stakeholder identification and analysis. Methods and tools for conducting stakeholder analysis are described in the subsequent chapter. Thereafter follows a chapter on social and organizational network analysis that looks at the interaction between stakeholders. Then two assessment approaches are described which help structure social assessments. These are: (a) the sustainable livelihood framework (SLF) and (b) perception and motivation assessment of which the protection motivation theory will be explained in more detail.

4.4.1 Stakeholder Identification and Analysis

Planning, designing, operating and maintaining a solid waste management project or activity is not a simple task. A wide and comprehensive understanding of the situation and local context is required. It is not sufficient to be a versatile expert "technician". Only a multidisciplinary approach, which considers natural science, engineering and social science can properly be used to help understand and address such multifaceted urban environmental situations (Benn et al., 2009). Understanding the context and local conditions must consider the perception, attitudes and roles of stakeholders. Stakeholders are all those people groups or organizations that are affected by the project and/or affect the project.

Identifying stakeholders and evaluating their characteristics uses method of stakeholders analysis. This is a systematic method that uses data (mostly qualitative) to determine the interests and influence of different stakeholders and stakeholder groups in relation to a project or activity (Schmeer, 1999). This method is typically used together and as part of social assessments or social impact assessments. Typically, stakeholder analysis identifies stakeholder groups to consider as categories for which representatives can provide the necessary information for the analysis. Stakeholders can also be specific organizations (NGOs, Universities etc.) or even governmental agencies or authorities (local government offices, ministries or departments of ministries). Stakeholder analysis is usually iterative, through a process or key informant interviews to identify stakeholders relevant to the issue. Here a diverse groups representing different interests should be consulted to avoid a bias in stakeholder identification (Overseas Development Administration, 1995). There are 3 steps in doing a stakeholder analysis (Schmeer, 1999):

- Identify stakeholders and develop a stakeholder table;
- Assess each stakeholder using interviews and questionnaires on aspects of attitude interest towards the project as well as the relative power and influence potential on affecting the project's success
- Identify risks and assumptions which will affect project design and success and devise appropriate mitigation strategies.

Identifying stakeholders can be conducted interactively during the interviews by asking who they think is not on the list but should be (Bryson, 2004). With this information the stakeholder list is continuously updated until no new stakeholders are mentioned.

Drawing out the interests of the stakeholders can be achieved by asking questions such as (Overseas Development Administration, 1995): What are your expectations of the project? What benefits are in it for you? What resources would you wish (or avoid) to commit to the project? What other interests do you have which may conflict with the project? How do you see other stakeholders in the list?

Three main types of stakeholder can be distinguished although the distinction may not be so clear-cut: (DFID, 2002):

- Key stakeholders are those who can influence the success of the project in a significant way.
- Primary stakeholders. This includes the individuals and groups who are ultimately affected beneficiaries (positively or negatively impacted)
- Secondary stakeholders are all the other individuals or groups, institutions or organizations with a stake, interest or intermediary role in the activity but not in a position of significant influence.

Analyzing a waste management system with this approach gives high visibility to the stakeholder knowledge and perception of the project or activity, rather than focusing only on the external observations of an experts. Stakeholder analysis, also called stakeholder mapping is a common approach used in development projects and thus frequently observed in a wide range of sector activities. In solid waste management research stakeholder analysis is also present as an embedded activity but is less prominent as a pronounced scientific approach. In Indonesia stakeholder analysis was carried out to investigate the performance of the vegetable market and the impact of solid waste from the market on the waste disposal site (Araki et al., 2008). In Pakistan and India the method was used to create a better understanding of participation in waste management activities (Snel and Ali, 1999). Similarly in Cairo, Egypt the method was used to identify the key issues and conflicts between privatization efforts and the recycling Zabaleen communities (Fahmi and Sutton, 2006). In Zhu (2008) an interesting case is described from Bangalore, India. Here, through engaging in a stakeholder analysis, the stakeholders themselves benefited by obtaining a more comprehensive picture of the overall stakeholder situation. By this they were able to improve their communication strategies to better target specific stakeholders with their expressed views and needs (Zhu et al., 2008). Geneletti (2010) uses spatial stakeholder analysis with multi-criteria evaluation to select and rank landfill sites (Geneletti, 2010). In sanitation research, Medilanski (2007) applied the method of stakeholder analysis to highlight institutional barriers and the relative importance of the degree of decision-making power and level of interest for urine separation before introducing this innovation into the urban area of Kunming, China (Medilanski et al., 2007). In Vietnam, stakeholder analysis was used to evaluate barriers to success of rural hygiene and sanitation promotion campaigns (Rheinländer et al., 2012).

4.4.2 Social and Organization Network Analysis

Social and organizational network analysis (SNA or ONA) complements stakeholder analysis by investigating the relationships among stakeholders (Holland, 2007). Whereas an organization chart shows formal relationships of function and responsibility, SNA aims at illuminating informal relationships: “who knows whom” and “who shares with whom” (Ramalingam, 2006). It maps and measures relationships and flows of information and goods between people, groups, or organizations. It visualizes people and groups through nodes and the respective links between nodes show the relationships or flows. SNA provides both the visual and mathematical analysis of relationships (Orgnet.com, 2011). This approach considers how the system is driven by knowledge contained in social actors, social roles and interaction among social actors in communicating and sharing information. An analysis by SNA can help identify:

- individuals and groups that play central roles in terms of influence over the others
- individuals and groups which are knowledge hubs and that broker information
- how information is passed on to others, where the bottlenecks are and who is isolated
- which and how measures can be implemented to enhance exchange and sharing monitor improvements over time (Ramalingam, 2006)

Conducting a SNA involves collecting information on these interaction by means of questionnaires and/or interviews. Based on the defined scope of the analysis, questions are then targeted to identify a defined specific relationship among stakeholders. Once the data is collected, a wide range of software tools can assist with mapping and mathematically assessing the network.

Net-Map is a network analysis tool which was specifically established to support development projects. It helps stakeholders visualize, discuss, and thereby understand and improve specific situations influence by many different actors (netmap.wordpress.com). This tool allows to develop “Influence Network Maps”. In these maps individuals and groups can share their view of a situation. This enhances, discussion, and assists the users in developing a strategic approach to their networking activities. The tool is simple and cheap and works in rural community with limited education but also with policy makers or international development actors (Schiffer and Peakes, 2009).

Only very few scientific literature related to solid waste management issues could be identified which systematically use SNA in their study framework. Social networks can be attributed to one of the four elements of social capital - social trust, institutional trust, social networks and compliance with social norms. In this context therefore social networks are frequently implicitly included in studies on social capital (Jones et al., 2011). Social capital relates to the value of social ties. In other words it depicts the importance of social relations and how these are used to achieve positive outcomes. Many studies show that there is a positive relationship between social capital and the intensity of social network use (Borgatti et al., 2009). Related to solid waste management, Everett (1992) shows the linkage of social network and collective action. Results show how the relationships among block leaders of curbside recycling

influence participation of residents. This study also shows how higher participation in the recycling program is connected to higher "social tie density" (a measure of how well block residents know each other), and higher "social tie centralization" (a measure of how well the block leader knows block residents) (Everett and Peirce, 1992).

4.4.3 Institutional Assessment

Closely linked to stakeholder analysis and organizational network analysis is the assessment of institutions, often called institutional mapping (Aligica, 2006). Aligica (2006) describes its importance as: *"…any social change initiative or any policy project needs, for strategic and tactical reasons, to get an inventory of institutions involved, identify the key players, assess potential support or opposition among them and to highlight the relevant institutions' roles and the inter institutional linkages"* and *"…stakeholder mapping and institutional mapping are not two separated procedures but the faces of the same coin…"* (Aligica, 2006). In social science, institutions are broadly defined as rules, formal or informal. In engineering the same term is however often used for governmental organizations. This can be merged to one, as certain entities (institutional organizations) are socially recognized to have the authority and power to structure and enforce rules (Aligica, 2006). The term governance adds to the concept of institutions with a dynamic perspective that focuses on processes of governing (SWITCH, 2011) and research in this field relates to the connections of rules and associated actions. In recent years the term "assessment of political economy" is also used to describe analysis of how political forces affect the choice of policies, which relates closely to the here described understanding of institutional assessment (Alesina, 2007). With regard to solid waste issues, an institutional analysis can help identify and assess (Morgan and Taschereau, 1996):

- local context in terms of roles, responsibilities as defined by legislation and policy, environmental rules, policy and planning frameworks, political drivers, key institutions, governance processes and actors
- how governments make decisions
- processes at national and sector levels related to environment and services of public good
- links or lack of links between institutions
- institutional incentives, opportunities and blockages that may influence change
- potential champions in government, civil society, private sector, etc.

For the sector of solid waste management in low- and middle-income countries, description and qualitative analysis of institutional settings is widespread in literature. Typical common features mentioned in literature that are typical for low-income countries are unclear and fragmented roles and responsibilities of different national, provincial and local agencies. This fragmentation combined with the lack of coordination frequently results in contradicting actions by various stakeholders or even duplication of efforts thus wasting of resources. Lack of legislation is partially responsible for fragmentation of responsibilities. When legislation exists, lack of enforcement is common (Ogawa, 1996).

4.4.4 Sustainable Livelihood Framework

The Sustainable Livelihood Framework (SLF) was developed and promoted by the Department for International Development of the United Kingdom (DFID). It is a tool to enhance the understanding of livelihoods, main factors that affect livelihoods (especially of the poor) and the typical relationships between these factors. At the centre of the framework, closest to the people, are the livelihood assets (also called "capital") which people have access to and can use (Figure 13). These assets are:

- *Physical assets:* includes the basic physical infrastructures and goods needed to support livelihoods, like habitat, transport equipment, water supply and sanitation systems and technologies, energy system, and communication technologies.
- *Financial assets:* which includes various kinds of savings (in bank deposits, livestock, jewelry, etc.) and regular financial flows (salaries, pensions, remittances, etc.).
- *Natural assets:* which comprise access to functional ecosystem services (water, air, soil nutrients and soil quality, biodiversity, etc.)
- *Human assets:* which represent the health and ability to labor as well as the skills and knowledge to put this labor to good use for livelihood opportunities
- *Social assets:* comprises the access and availability of networks and social connectedness, the trust and ability to work together and help each other, and the access to wider institutions, such as political or civic bodies;

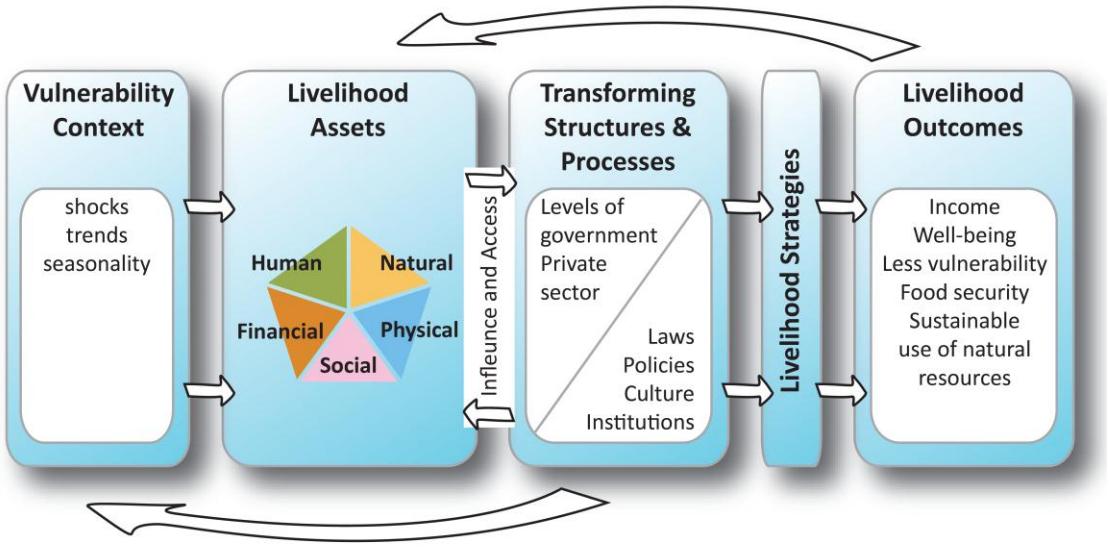


Figure 13 The sustainable livelihood framework. Arrows within the framework are used to show different types of relationships (DFID, 1999).

Access and availability of assets can be both destroyed and created as a result of the trends, shocks and seasonality of a vulnerability context, or by the typical social, institutional and political context (also called the transforming structures and processes). This "Vulnerability Context" and the "Transforming Structures and Processes" both affect how people can use their assets to achieve their goals (DFID, 1999). Government policies for instance, as one element of the "Transforming

Structures and Processes", can enhance physical assets (infrastructure), human capital (education) or financial assets (taxation). These can also be bidirectional relationships where also individuals and groups can influence the "Transforming Structures and Processes" for instance through their social capital (DFID, 1999).

In waste management research and practice certain asset categories have been studied in detail however, the framework of SLF has seldom been used. Willingness to pay for waste services and livelihood opportunities (income) through recycling are the most prominent themes in this regard. Studies have looked into social capital as a cornerstone for community action. Pargal et al. (1999,2000) show that trust, reciprocity and sharing can capture different aspects of social capital and how the level of social capital is an important determinant of whether voluntary solid waste management systems in neighborhoods exist of not. Thus, social capital determinants can be used as predictors of success when targeting neighborhoods for self-organized waste management activities (Pargal et al., 1999). Beall (1997) on the other hand argues, based on studies in India and Pakistan, that a focus on social capital alone masks the importance of local power structures and the effects of the "Transforming Structures and Processes" (Beall, 1997).

4.4.5 Perception and Motivation Assessment

With the book, "Small is Beautiful - Economics as If People Mattered" by Schumacher, the importance of people in the ownership of organization and action was highlighted (Ali, 2006). Since Schumacher's book, a number of organizations and individuals have embraced the concept of people-centeredness. Understand what people want, what drives them and how they perceived things is considered fundamental to all sustainable development projects and is also true for solid waste management activities. For a well-functioning solid waste management activity, acceptance by all actors, and participation with a certain behavior, is important. A group of assessment methods exist that focus on how perceptions, motivation and "behavior change" can be assessed and evaluated to then design more effective strategic interventions. Most of these methods originate from disciplinary field of psychology or social-psychology.

Stakeholder analysis and social network analysis already provide valuable tools to assess people views, relations and motivations. A more in-depth analysis of behavior can be assessed however, with the help of the RANAS model. This integrates aspects of (Mosler, 2012) :

- risk perception: which entails perceived vulnerability and perceived severity of the threat by a certain situation or newly proposed option
- attitudes: comprising beliefs about costs and benefits of the situation or newly proposed option or personal feelings arising when thinking about required changes in behavior to enable the newly proposed option
- norms: which includes personal standards on what should be done, valuing what is typically performed by others, and what might be typically approved or disapproved by others
- perceived abilities: which comprises perception to perform and manage a certain behavior

- self-regulation: which includes the ability to remember to act in a certain way, and maintain this behavior over time.

Several theories of behavioral change underlie these aspects (Mosler, 2012). One specific approach stemming from health risk behavior is “Protection Motivation Theory” (PMT) (Rogers, 1975). It reflects a theory of persuasive communication, emphasizing the cognitive processes that mediate behavior change. “Protection Motivation Theory” suggest that motivation or intention to act towards a mechanism of protection will depend upon four factors:

1) the perceived severity of a hazardous event
2) the perceived probability of the occurrence of the hazard
3) the perceived efficacy of one’s response
4) the confidence in one’s ability to undertake the behavior/response.

Interview, with protocols, and subsequent analysis are the methods of inquiry to better understand which of these factors are decisive for different stakeholders and how programs can be specifically targeted to strengthen those elements shown to be important to foster sustainable change.

Behavior change models and assessments have been used frequently concerning aspects of hygiene practice (Mosler, 2012; Peal et al., 2010). In solid waste management, Geller and Lehman (1986) applied behavior analysis to better understand and control littering, waste reduction, and resource recovery. The model of antecedent-behavior-consequence (ABC) was hereby used as a framework (Geller and Lehman, 1986). The ABC model helps review a sequence of events related to challenging a certain behavior, where the specific event happening immediately before a behavior is analyzed, then the behavior event itself is observed, and finally the event that immediately follows the challenging behavior is analyzed. Antecedents can be accessibility or availability of equipment and infrastructure (e.g. waste bins) and consequence strategies can be categorized as positive reinforcements or punishments. Evidence by Geller and Lehman (1986) show that antecedent strategies alone are rarely sufficient to encourage a change in behavior. Consequence strategies on the other hand are quite work and capital intensive or need to be based on the perceived importance of “norms”. Sharp et al. (2010) used behavior change models to understand what can be achieved with household waste prevention campaigns (Sharp et al., 2010). Al-Khatib et al. (2010) studied household attitudes in Palestine, however they did not pursue the next step to identify what households would accept to do (behavioral change) to improve their situation (Al-Khatib et al., 2010). In such surveys a typical pattern emerges where the residents blame the authorities for not doing their job properly and the authorities blame the residents for not doing what the solid waste management plan expects then to do (e.g. not litter).

4.5 Organizational Aspects

A well-functioning solid waste system requires adequate organizational strength of the involved governmental authority or of a respective private sector stakeholder. The assessment of the organizational strength has the objective to answer the following questions:

- Does the organization have a clear organizational status and is it justified to do what it is doing?
- Does the organization have a clear and specific business strategy and coherent model, independent of its organizational form or affiliation?
- Does the organization rely on committed skill staff and strong leadership?
- Does the organization have the ability to interact with other stakeholders in the system, to structure and maintain a successful cooperation?

4.5.1 Business Canvas and Business Model Assessment

Using a concept of business model visualized by a business canvas, Osterwalder and Pigneur (2010) describe nine important systematic elements that can describe any organization's complete business:

1. *Value Proposition:* this illustrates the product/service, its features and benefits and the size of the market opportunity. In waste management it is typically a service but can also be a product which is derived from waste (compost, biogas, etc.).
2. *Customer Segments:* this entails asking yourself who your customer is and what problems/needs the product or service resolves (benefits as seen from the customer perspective). For solid waste collection service the most typical customer is the waste generator, wanting to get rid of the waste and willing to pay for this service. However, it may also be the government which is the direct customer acting from a perspective of public interest to "want" the waste management service and paying the organization to do it. For the example of recyclables trading, it is the sale of these to clearly identifiable customers which want and need the recycled material.
3. *Channels:* describes how the product or service shall be distributed. In waste collection this typically refers to the means how the service will be provided to customers.
4. *Customer Relationships:* this regards how the organization will relate, communicate and interact with the customers to create and maintain demand and satisfaction.
5. *Cost Structure:* which comprises the evaluation of investment and operational costs required to operate the business well.
6. *Key Activities:* comprises the tasks the organization must perform to succeed.
7. *Key Resources:* this analyzes the required supply chains (e.g. equipment suppliers), staff skill set and capacities, commodities and natural resources, which are essential for operating the business. In the case of recycling it is the material itself which is the resource needed. For collection it is also the waste, but in addition it will also comprise the collection vehicles, land, equipment, energy, water for the treatment, etc.
8. *Key Partners:* this involves a careful analysis of other organizations and partners which are essential to success of the business. In waste management service this can be the regulator or the cooperation among a wide range of stakeholders.
9. *Revenue Streams:* comprises an in-depth analysis of revenue sources and amounts needed to recover costs and gain profit. In governmental waste management "profit" is not necessarily a goal. However revenues should at least

be able to recover “full cost”. The means by which revenues are obtained can vary; either directly from the households for which the service is provided, or indirectly through property or income tax.

All these elements can visualized with a business canvas as shown in Figure 14. This helps to attain a full-picture of the business model with its strengths and weaknesses (risks).

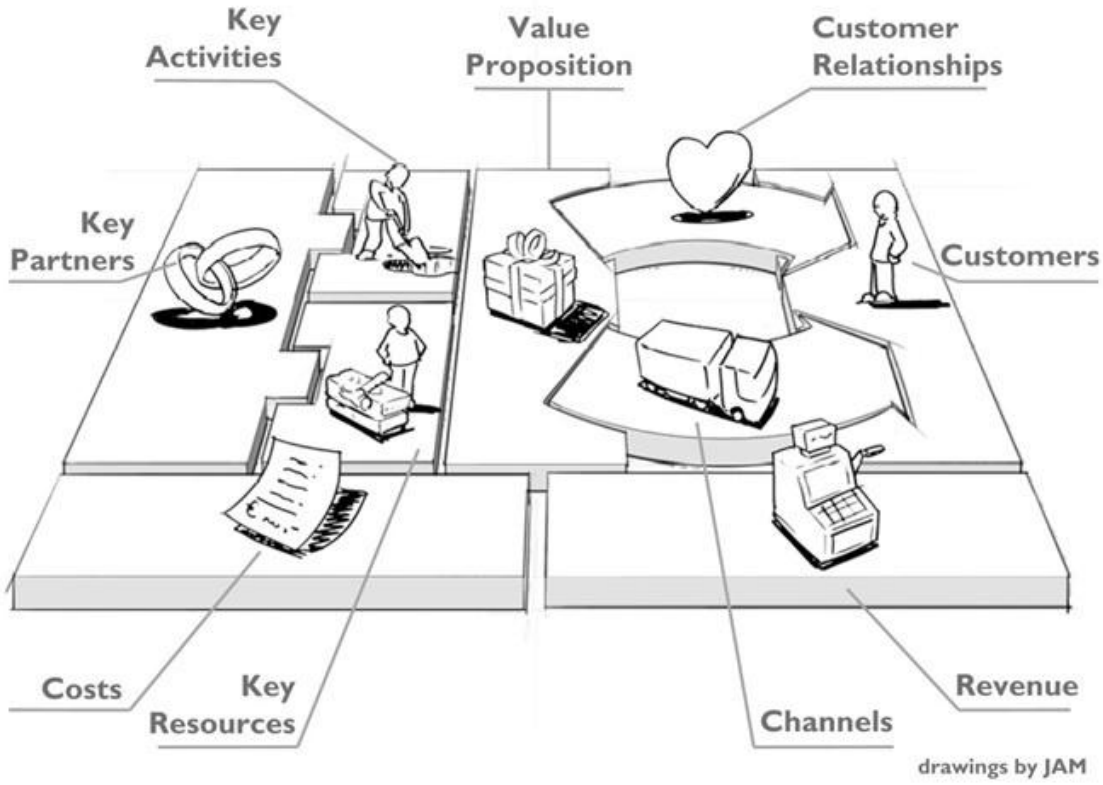


Figure 14 Elements of the Business Canvas (Osterwalder and Pigneur, 2010).

With regard to business model development and assessment, one decisive element is the understanding the enabling environment (see Chapter 3.2.2) and assessing how this “environment” has evolved and how it could further evolve in future. This then allows to assess under which conditions and assumptions the “environment” might positively or negatively influence the proposed venture (Griffiths and Wall, 2004; Gillespie, 2007). Gillespie (2007) distinguishes between a micro-environment and a macro-environment. The micro-environment concerns the individuals or other organizations that the business deals with on a regular basis (e.g. suppliers, distributors, customers, employees, etc.). The macro-environment on the other hand contains factors which are not in direct control of the business. Such “external“ environments can also be evaluated using a tool called “STEEPLED analysis”. This structures the assessment according to the following dimensions: Social, Technological, Economic, Environmental, Political, Legislative, Ethical and Demographic (Larsen et al., 2010). For each of these dimensions the assessment describes the current status, and then projects different future scenarios. For each feasible scenario, the consequences on the proposed project/business are then evaluated.

One example of assessing the market environment and its effect on the business is shown in Rouse et al. (2008) for the example of waste composting (Figure 15).

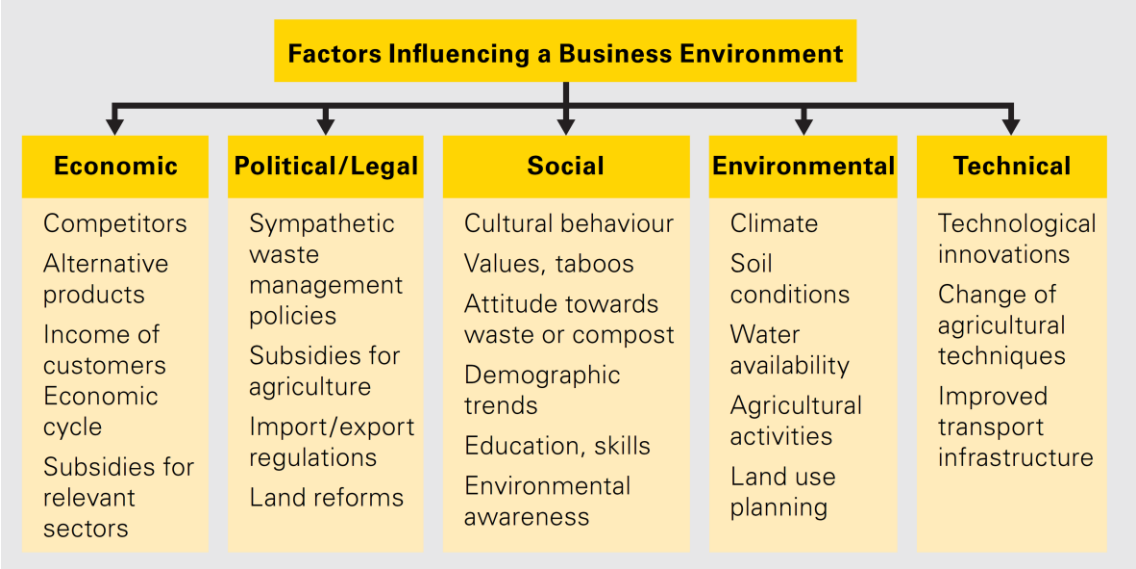


Figure 15 Factors influencing a business environment, for the example of compost marketing, source (Rouse et al., 2008)

Another helpful method is to put the proposed business model into an overall perspective using SWOT analysis - Strengths, Weaknesses, Opportunities and Threats (also abbreviated by SFOT – Successes, Failures, Opportunities, Threats, Figure 16).

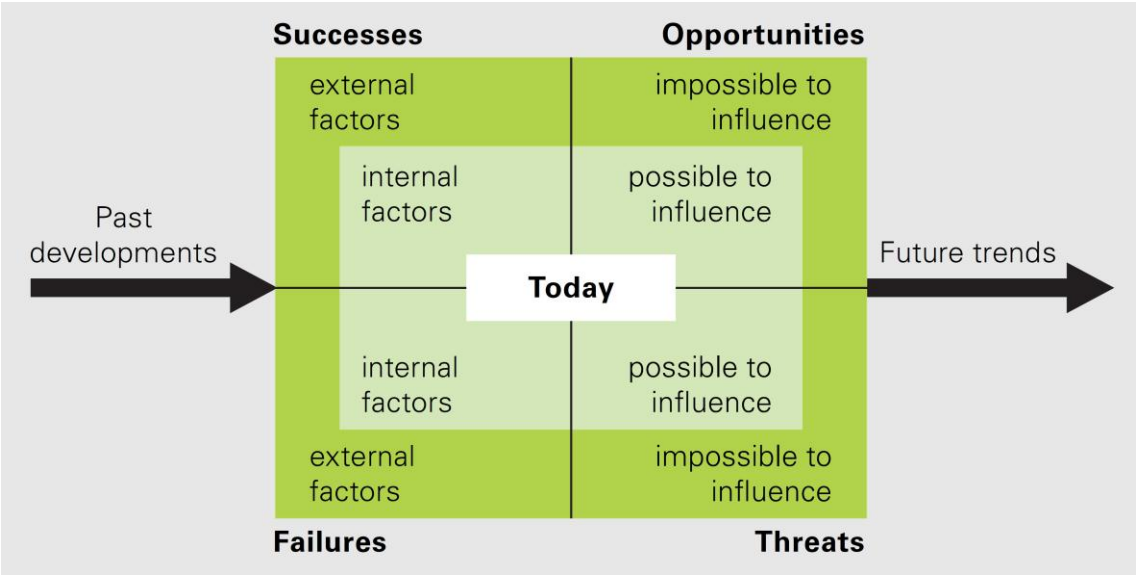


Figure 16 Matrix to evaluate success, opportunities, failures or threats for the business venture, source (Rouse et al., 2008)

Here strengths and weaknesses focus on internal organizational aspects whereas the opportunities and threats consider the future external environment impacting on the organization. Rouse et al (2008) suggest to take each element from the market

environment (Figure 15) and then consider how they might change in short and long-term. Each factor can then be ranked according to: (a) the significance of its potential effect; (b) the imminence – i.e. how soon they will have an impact; and (c) the degree to which it is possible to react, either to maximize benefits from the opportunity or minimize the effects of a threat (Rouse et al., 2008).

4.5.2 Collaboration and Cooperation

Solid waste management involves many stakeholders. They can be formal or informal organizations, institutions, or individuals from different societal sectors. It is the interaction and collaboration between these stakeholders which is crucial to success, whatever the type project. Waste collection service, needs cooperation of the households as to place their waste at the curb on defined days. It also needs their collaboration when payment is due. A few principles of successful collaboration are (UN-Habitat, 2001):

- Early involvement of all participants and sufficient time.
- Willingness to participate (valuing the benefits).
- Transparency.
- Cultured conflict: This is not an absence of disagreement; but rather ensure that all views are represented. All of those involved listen to each other, take other perspectives seriously, and attempt to address the voiced concerns.
- Sustained dialogue which seeks consensus.
- Capacity of facilitation, monitoring, evaluation.

Participatory methods and techniques are now central tools in community development and the there is a continuously growing set of tools to foster participation, transparency and accountability (UN-Habitat, 2001).

Any organization that is in charge of solid waste management, independent of its organizational status (e.g. community-based, cooperative, informal private sector, formal private sector, NGO or governmental) must have or develop the ability to communicate, coordinate and collaborate with the wide range of stakeholders. This is a large challenge for most, as municipal officers generally feel that this is not their job description and they receive no training in communication, outreach, leadership, and collaborative problem solving. They frequently lack the capacity to fulfill the role of facilitator and mediator. The lack of integration of the informal recycling sector into the overall waste management strategy is the most prominent example of this challenge to integrate and cooperate (Scheinberg, 2001b; Scheinberg et al., 2010). Although the informal are becoming increasingly involved in the various stages of solid waste management, questions remain as to whether their inclusion is participation or information. For each actor and organization involved organizational (and individual) capacity and strength applies. Certain organization structures may already induce specific weaknesses. Pfammatter (1996) describes non-governmental collection schemes and highlights the weakness of community-based structures compared to microenterprises (Pfammatter and Schertenleib, 1996). A business based organization (which is more common in the enterprise model) correlate with a careful financial management. On the other hand Zurbrugg (1999) shows that community-based system have the advantage to be more socially inclusive. In Pakistan community-based

primary collection schemes exempt widows, which have no source of income, from their monthly waste collection fees (Zurbrügg and Rehan, 1999).

4.6 Integrated Sustainability Assessment

Sustainability assessment is described as a process in which the impact of a policy, legislation, plan, program, project, practice or activity, on sustainability is evaluated (Pope et al., 2004). Many of these have their underpinning in environmental impact assessment (EIA) or strategic environmental assessment (SEA), but then are extended to include social and economic considerations. This reflects the 'triple bottom line' (TBL) approach to sustainability (Pope et al., 2004).

Achieving the broad goals of sustainability in solid waste management, often involves assessing and compromising on inherent trade-offs among the specific dimensions of sustainability and this is usually a balancing act. Beneficial developments in one dimension of sustainability may affect practices or activities in another dimension, either in a emphasizing or offsetting manner (UNEP, 2005b). Cheapest waste management strategies in the way of economics may not be the most environmentally benign. The most suitable option in terms of social equity may not be the best one to meet the economic or environmental goals (Chang et al., 2011). It is therefore necessary to clearly structure, analyze and understand these interactions in all instance of the project cycle.

This chapter analyses methods and selected assessment tools which are broader in scope as the methods discussed in previous chapters. The tools are not specific to solid waste management activities but rather encompass all kinds of development projects. A stronger focus was given to those tools which are embedded and used in development practice rather than those that are solely of academic significance.

4.6.1 Aspire Assessment

ASPIRE is a tool which assists with integrated planning, monitoring and evaluation and helps appraise the sustainability and poverty reduction performance of infrastructure projects. It was developed through a partnership between Arup and Engineers Against Poverty (EAP), with support from the Institution of Civil Engineers Research and Development Enabling Fund as well as Arup's internal Design & Technical Fund and EAP programme (ARUP, 2008). In ASPIRE, attention is given to infrastructure and its contribution to poverty reduction considering the relationship how infrastructure:

- Provides affordable services for the poor, fulfils basic human needs, reduces vulnerability and allows participation in economic activities.
- Enhances employment generation in construction, operation and maintenance
- Supports individuals and communities to engage in decision making to guide wellbeing and livelihoods.
- Reduces the consumption of natural resources and respective impact on the ecological environment.
- Is financially, operationally and institutionally viable in the long term

- Is developed, operated and maintained using a holistic approach which considers social, environmental and economic aspects.

The ASPIRE conceptual framework considers four dimensions: society, environment, economic and institutions. The four dimensions are subdivided into 20 primary theme areas and each primary theme again into 4-5 sub-themes which indicators to help assess the performance of the project in that specific sub-theme (see Annex 3 for the list of criteria). The criteria and indicators considered in ASPIRE relate to qualitative information and cover issues particularly relevant to developing country contexts. The tool can be used throughout the project cycle, as a planning tool to identify priorities and support decision making or also as an evaluation tool to assess project performance (ARUP, 2008). A keystone diagram is one output of the assessment with traffic light colouring for the level of sustainability achieved (Figure 17).

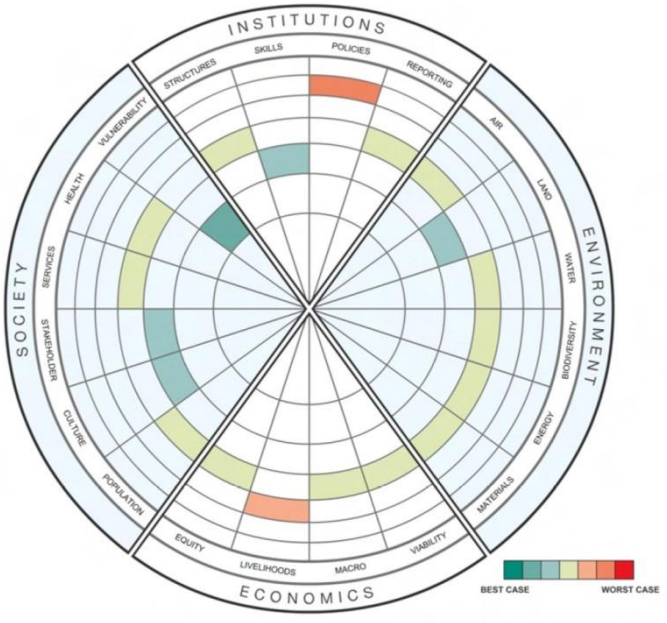


Figure 17 ASPIRE keystone diagram output, source (ARUP, 2008)

4.6.2 SDC Sustainability Assessment Tool for WASH

This tool is currently being developed as an integral part of the Swiss Agency for Development and Cooperation's (SDC) Sector Policy on Water Supply and Sanitation. It uses a basic set of indicators which consider social, economic, environmental, institutional, technological and knowledge issues. The tools aim is to support, planning, and monitoring of programs and projects. Although developed for water and sanitation projects it is well applicable also to solid waste projects. Using a Excel-software format it guides the user through various thematic sheets where qualitative judgments of the user or of stakeholder groups are required to answer specific question related to sustainability of projects (SKAT, 2012). Six dimensions of sustainability are considered with 3-5 subthemes each (Figure 18). The results are summarized and visualized in a table and a spider diagram. This tool can be used in all

phases of the project cycle and is especially recommended to evaluate programs and projects over time to assess their respective improvements (Montangero, 2012).

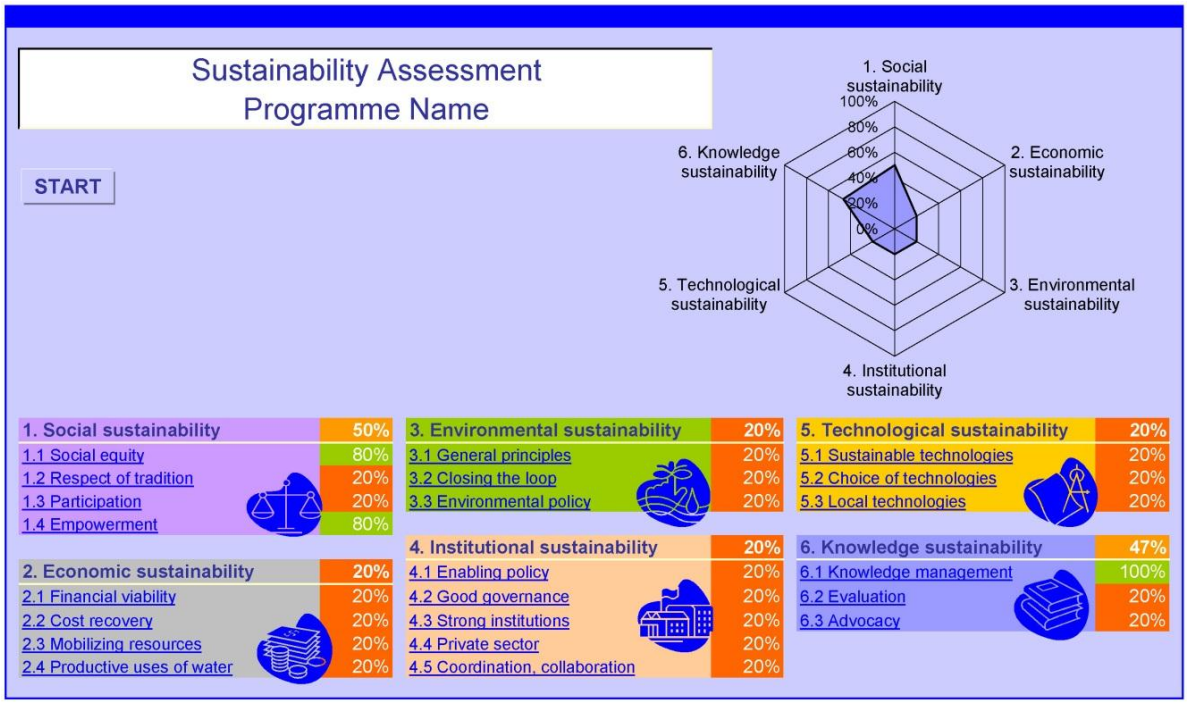


Figure 18 Excel-based sustainability assessment sheet for water and sanitation projects (Montangero, 2012).

A question-based approach has been developed to assist the users with evaluating sustainability under the subthemes (Table 9).

Table 9 Question-based sustainability assessment for water and sanitation projects, adapted to solid waste management issues, adapted from (SKAT, 2012).

1 Social field
1.1 Social equity: Are the specific needs and potentials of all groups: women, men, children, elderly, marginalized, disabled, the different religious and ethnic groups, etc. addressed?
1.2 Traditions: Are traditional practices and traditionally grown rules, rights and decision-making processes of the different interest groups and social segments related to waste integrated in the interventions?
1.3 Participation: Do all stakeholder groups participate in all phases of the program/project: definition of the problems/objectives, planning, design and implementation? Do all stakeholder groups have sufficient knowledge at hand to make well-informed choices and decisions? Does the population own the project?
1.4 Empowerment: Are local structures (development committees, user groups, consumer associations and elected representatives, etc.) strengthened (or formed)? Are investment done in training measures, behavioral change promotion, building up conflict management capacities? Are women's' skills developed, their opportunities for positions in decision-making created, and their experience, skills and ability to define and solve their own problems recognized?
2 Economic field
2.1 Financial viability: Is the proposed system financially viable, managed with responsibility, accountability and transparency?
2.2 Cost recovery: Are the burdens of services borne equitably by the different sections of the stakeholder community?
2.3 Mobilizing and managing resources: Does the project/program appropriately contribute to mobilizing and managing resources?

2.4 Productive uses of waste: Does the intervention contribute to economic benefit through non-domestic productive solid waste recycling/reuse?
3 Environmental field
3.1 General principles: Are negative impacts of the project/program on the physical environment and on downstream users minimized?
3.2 Circular system of resource management: Does the project/program contribute to resource conservation and environmental protection by reducing waste-generating imports and maximizing recycling and reuse of resources used?
3.3 Policy, legal framework, financing mechanisms: Does the project/program contribute to the development of a policy and a legal framework promoting the development and application of environmentally sound solutions? Are financing mechanisms planned/in place that provide incentives to conserve resources and protect the environment?
4 Institutional field
4.1 Policy and legal framework: Does the project/program contribute to the development of national or sub-national policies (a set of procedures, rules, priorities and allocation mechanisms), legal framework and means for their enforcement providing the basis for sustainable services?
4.2 Good governance: Are roles and responsibilities of all stakeholders clearly defined, appropriate and locally adjusted? Are interrelations between all stakeholders founded upon participation, transparency, accountability, non-discrimination and the effectiveness and reliability of public affairs?
4.3 Strong and competent institutions: Are institutions strong and competent at local and national level?
4.4 Private sector involvement: Is the local (and national) private sector encouraged to invest and to provide efficient and effective services?
4.5 Sectoral and multi-sectoral coordination and collaboration: Is sector coordination and collaboration between government institutions, the civil society, the private sector and the donors effective? Are communication and collaboration with other sectors appropriate and effective?
5 Technological field
5.1 Sustainable technologies/services: Does the intervention improve the technology or the quality of service? Is the appropriate use of products (technology & services) promoted, which respond to the demands of the poor people, are gender specific and affordable ?
5.2 Choice of technologies: Is the choice of technology guided by the search for affordable solutions, which are acceptable to the users and appropriate to the situation?
5.3 Local technologies: Are the systems built and maintained with local material and know-how?
6 Knowledge field
6.1 Knowledge management: Are lessons shared with all stakeholders in the project as well as with stakeholders from other projects? Are these lessons put into practice?
6.2 Monitoring and evaluation: Is the performance of services adequately and regularly assessed?
6.3 Advocacy: Does the project/program advocate on solid waste issues?

4.6.3 Sustainability Assessment by Success and Efficiency factors

Other approaches towards sustainability assessment use experience and learning from development projects. This approach is based on establishing what works and why (success factors) and then translating this into an overall framework of analysis. This chapter presents examples of such research and development. They are not only focused on solid waste management projects but are considered to have great potential and can be easily adapted for application to waste issues.

For solid waste collection schemes in low-income countries, a list of success and sustainability indicators was developed by the UK Department for International Development (DFID) based on collection schemes in South Asian cities (Appleton et al.,

2000). This approach takes different stakeholder perspectives into consideration by judging their views. The stakeholders considered are: users, municipality, non-governmental organization (NGO), community-based organization (CBO), local politician, small contractor and sweepers. The issues assessed, are general performance factors such as area cleanliness, area improvement, user satisfaction, or reliability. Other questions are then only directed towards specific stakeholders, e.g. affordability, increase in property value, complaints system, replicability, or recognition. Application of this tool in the city of Khulna, Bangladesh identified interesting weaknesses with NGO initiated waste collection projects. Results show in the situation where the initiator of the scheme will eventually phase-out activities, it is crucial that appropriate skills development and training be established early on in the project and a well-defined withdrawal plan is developed and clearly communicated to the beneficiaries (Appleton et al., 2000). Similarly UNEP (2005) developed an approach to assess performance of solid waste services for Asian cities. This approach uses a point system and performance indicators, that follow the principles of integrated waste management. Applied to different cases, the method then allows comparison of results (UNEP, 2005a). However conducting an assessment with this tool does not allow the user to identify the critical factors of strength or weakness but rather assists in establishing a comprehensive situation analysis.

Montgomery et al. (2009) extracted “universal” sustainability factors for rural water and sanitation services from existing literature. These are identified as: (a) effective community demand, (b) local financing and cost recovery, and (c) dynamic operation and maintenance. The first two are quite straightforward, whereas the term “dynamic operation and maintenance” needs to be better defined and explained. It is cited as being the one aspect largely overlooked by providers, operators and managers of water and sanitation service suppliers. It comprises clear management responsibilities, access to spare parts and technical expertise, monitoring & evaluation and ongoing outreach and support to customers (Montgomery et al., 2009).

McConville and Mihelcic (2007) link five project cycle phases to the traditional domains of social, economic and environmental sustainability whereby social sustainability is split into 3 different aspects: sociocultural respect, community participation and political cohesion (McConville and Mihelcic, 2007). The five project cycle phases comprise: (a) Needs assessment; (b) Conceptual designs and feasibility; (c) Design and action planning; (e) Implementation; and (f) Operation and maintenance. The resulting 5x5 matrix is evaluated with the help of guiding questions (McConville, 2006).

For the selection of a sanitation system Willetts et al. (2010) developed a matrix of sustainability criteria. The the five broad areas of concern were identified as: (i) technical and risk (ii) social and health (iii) environment (iv) economic and financial (v) contribution to the city’s future (Willetts et al., 2010). For each of these areas of concern, criteria were developed together with local stakeholders (Table 10).

Related to faecal sludge and wastewater treatment, a study conducted in Dakar developed a methodology to evaluate the success and failure of projects (Bassan et al., 2012). The study includes criteria that were identified in literature and which were then further discussed during interviews with stakeholder groups (Table 11).

Table 10 Matrix of sustainability criteria for selection of a sanitation system (Willetts et al., 2010).

Techn. & Risk	Social & Health	Environmental	Economic	City Future
System robustness	Public acceptability	Impact on water	Net present value	Positioning of city as innovation
System complexity	Equity between groups	Energy use and GHG	Operation and maintenance costs	Contribution to socio-economic development of city
Proven technology	Contribution to public health	Nutrients reuse potential	Cost sharing	Contribution to capacity building
Risk of not being completed	Employment generation	Ability to cope with climate change	Cost recovery potential	Resilience and adaptability to uncertainty
			Land use investment	

The main dimensions of assessment are: a) Institutional Management; b) Technical Design (e.g. treatment efficiency, O&M); and c) Financial and Energy Resources (e.g. financial sustainability, and energy usage). Each of the three dimensions were then further broken down into criteria, sub-criteria and indicators, which every level down, represent a more detailed level of information to be assessed. The study highlights the importance of the administrative and decisional process in the success and failure of treatment plants. At technical level, the most decisive criteria is considered to be the quality of design studies and concepts that are elaborated during early stages of projects. Furthermore, three important factors are identified that improve the operation and maintenance as well as influencing national sanitation strategies. These are: (a) monitoring, evaluation and optimization skills, (b) the by-product valorization, and (c) optimization of energy usage (Bassan et al., 2012).

Finally, the International Water Association (IWA) has developed an assessment methodology to help assess why utilities function well (and can be considered efficient) or why they struggle to provide adequate service (IWA, 2011). This Water Utility Efficiency (Self) Assessment methodology analyzes efficiency of the following six areas using an excel based workbook for download:

- *Corporate Governance:* This comprises factors such as the availability and quality of a mission statement, business strategy, board of directors, code of conduct & internal accountability, procedures and quality control, procurement, public relations, professional bodies, and accountability to environment.
- *Human Resources,* which includes: internal communications, recruitment and staffing levels, remuneration levels, and staff training & education programs
- *Accountability towards customers,* which involves: coverage, delivery of service, quality of service, customer communication, customer services, and complaints management
- *Financial factors,* which comprise existence and quality of: financial operating projections, capital planning and projections, accounting principles and procedures, financial reporting and monitoring, external auditing of annual

financial records, credit worthiness, tariff setting policies and mechanism, and revenue sufficiency

- *Commercial approach* includes: customer information, meter reading and billing, and tariff collection efficiency from all clients
- *Technical appropriateness* and management which involves: risk management (e.g. water safety plans), infrastructure and equipment asset management, operational efficiency, maintenance, monitoring of technical functionality

Table 11 Criteria and sub-criteria used for assessing a sanitation utility in Senegal (Bassan et al., 2012).

Institutional domain	
Institutional status	Institutional autonomy
Country Education	Access to education (on sanitation)
Decision making process	Internal communication Capitalization of knowledge Handling of technician request
Human resource management	Availability and commitment of staff Education level and continuous education
Leadership expertise	Management ability Planning ability
Operational expertise	Operation and maintenance skills
Private consultant expertise	Availability & accessibility to external competencies
Social integration	Internal participation in processes Salary compensation

Technical Domain	
Quality of preliminary study	Quality of methodological approach
Operation and maintenance constraints	Response to O&M needs
Monitoring, evaluation and optimization	Monitoring quality Skill for analysis and optimization

Financial and Energy Resources	
Financial balance	Budget planning Funding ability Valorization to increase revenue
Energetic balance	Dependency on external energy Optimization of energy usage

4.6.4 Integrated Modeling Systems

Many decision support models integrate a variety of tools and methods as described in the previous chapters (e.g. LCA, Cost-Benefit, etc.) using predefined criteria in the various sustainability domains. Some also integrate spatial information through geographic information systems (GIS) and multi-criteria decision analysis (MCDA).

A review by Shmelev and Powell (2006) on waste management models concluded that most models do not have a holistic view over the solid waste management system, but rather tend to focus on a single problem (Shmeleva and Powell, 2006). However, there

is a clear trend in research to establish more comprehensive models which take into account a large amount of data from different sustainability domains. Abeliotis et al. (2009) distinguished two main categories of decision support systems (DSS) that are applied to solid waste management (Abeliotis et al., 2009). The first type is based on statistical computations and optimization by simulation modeling. Such models, for instance, help predict solid waste generation or use spatial multi-criteria to site landfills, waste treatment facilities (Galante et al., 2010) or waste bin placement. Furthermore such models can solve optimal routing problems for the collection of municipal waste (Ghoze et al., 2006; de Oliveira Simonetto and Borenstein, 2007; Ferretti and Pomarico, 2012) or apply non-linear optimization of the cost function considering regulations on recycling, incineration, sanitary landfill conservation, and mass balance (Fiorucci et al., 2003).

Table 12 Most frequently cited computer based waste management models.

Model name	Scope	References
MIMES/Waste	optimization of integrated material flows and energy systems based on nonlinear programming	(Eriksson et al., 2003; Söderman and Sundberg, 2004; Sundberg et al., 1994)
LCA-IWM	LCA based includes optimization of cost as well as social aspects (odour, visual etc.)	(den Boer et al., 2007)
IWM-2 LCI	LCI-based linked to an economic assessment model	(Al-Salem and Lettieri, 2009; Batool and Ch, 2009) (McDougall et al., 2001)
ORWARE	Based on annual substance flows (MFA), environmental impacts (LCIA) , and costs of waste management based using static conditions and linear programming.	(Assefa et al., 2005; Eriksson and Bisaillon, 2011; Eriksson et al., 2002)
WISARD	Life cycle assessment package for recovery and disposal	(Feo and Malvano, 2009)
SCOLDSS	operational planning of solid waste collection systems	(de Oliveira Simonetto and Borenstein, 2007)
EASEWASTE	LCA-based for municipal solid waste	(Christensen et al., 2007) (Bhander et al., 2010; Boldrin et al., 2011)

A large number of waste management models are reviewed in Chang et al. (2011), Shekdar and Mistry (2001) and Kijak and Moy (2004) and the most frequently cited are listed in Table 12 . The most frequent technique embedded in the models is LCA. This is used as foundation onto which other decision criteria are added (Kijak and Moy, 2004). One such LCA-based model is EASEWASTE (with the revised version called EASETECH), developed by the Technical University of Denmark. It calculates waste mass flow as well as substance flows, various forms of resource consumption (including energy consumption or generation) and a diversity of environmental emissions. It also provides a complete impact assessment regarding global warming, ozone depletion, photochemical ozone formation, acidification, nutrient enrichment, ecotoxicity and human toxicity (Christensen et al., 2007). The model provides default data for waste composition, collection, transport, various treatment processes and includes estimates of electricity consumption and heat production. In addition, the model also allows

input of data by the user, something considered essential for the use in developing countries, as most default values derived from cases in Europe would not be applicable. Other concerns such as economic costs, odor, dust, noise, ethical issues and social willingness towards a waste management system can be included into the model at a later stage (Kirkeby et al., 2006).

The second type of DSS are expert knowledge-based systems using a mix of qualitative and quantitative information. They adopt a multi-criteria analysis approach to provide assistance through structured rules and procedures (Abeliotis et al., 2009; Lohri, 2012). One such a model was applied to the case of Saharawi refugee camps (Algeria), for selection of waste management options in a multi-stakeholder environment (Garfì et al., 2009).

4.6.5 Multi Criteria Decision Analysis – AHP Method

Each alternative can be represented by its performance or sustainability in multiple criteria. Decision makers might want to sort or classify the alternatives based on a set of preferences and hope to achieve several – potentially conflicting – objectives with their choice. When many criteria are taken into account simultaneously, confusion can arise if no logical well-structured process is followed to value and judge the various criteria and assess how alternatives fulfil the intended objectives. Multi-criteria decision analysis (MCDA) methods provide help with this through a structured procedure which fosters transparency, coherence, consistency and comprehensiveness (Lohri, 2012; Lahdelma et al., 2000). Complexity increases when multiple stakeholders are involved which have differing preferences, or when there is uncertainty about the long-term consequences of any decision.

There are many methods and software tools which assist with multi-criteria decision analysis (DCLG, 2009). The two most cited outranking methods are: ELECTRE III and PROMETHEE II. They are commonly used as decision-aid in various environmental problems (Kangas et al., 2001). Outranking methods apply a threshold model to the original criteria. If the criteria values of the alternatives are sufficiently close to each other, they are indifferent to the decision maker. If however the difference between the criteria values is sufficiently large, this provides reason for a first ranking and screening (Kangas et al., 2001).

Another very common method is the Analytical Hierarchy Process (AHP) and its underlying pair-wise comparison technique. AHP is described here in more detail as it is considered well suited for multiple users and participatory planning and can integrate qualitative criteria, objective value information, expert knowledge as well as subjective preferences well (Ramanathan, 2001; TheQualityPortal.com, 2012).

In the AHP approach a first step consists of arranging the problem into a hierarchical structure of goal, criteria, sub-criteria and alternatives, with the hierarchies going from the general to the specific. Assigning relative weights to each criteria is then performed by pairwise comparison in a matrix. The user (or group of users) is requested to select the more important criteria from a pair of criteria. This is done for

all criteria compared to one another (CIFOR, 1999). At each hierarchy level, research has shown that users can handle a maximum of 7-12 criteria for comparison (Bouyssou, 1990). Based on the assigned value, the relative weights are then calculated using computed eigenvalues and eigenvectors. The consistency of the comparison matrix is also evaluated. The consistency index, CI, is calculated as: CI=(λ max - n)/(n - 1), where λ max is the maximum eigenvalue of the matrix and n is the number of elements in the matrix. This consistency index is then compared with the consistency index of a random matrix, RI. The ratio between the two (CI/RI), is the consistency ratio. Although AHP tolerates some inconsistency in the evaluation, a consistency ratio of 0.1 or below is recommended (Bhushan and Rai, 2004). Finally the alternatives are compared with each other for every sub-criteria. This scoring is then multiplied by the weights and aggregated for each sub-criteria which the again is multiplied by the weights of the criteria and aggregated to overall scores. The computations can be performed using spreadsheet software such as Microsoft-Excel, or else using a decision-support software package such as "ExpertChoice".

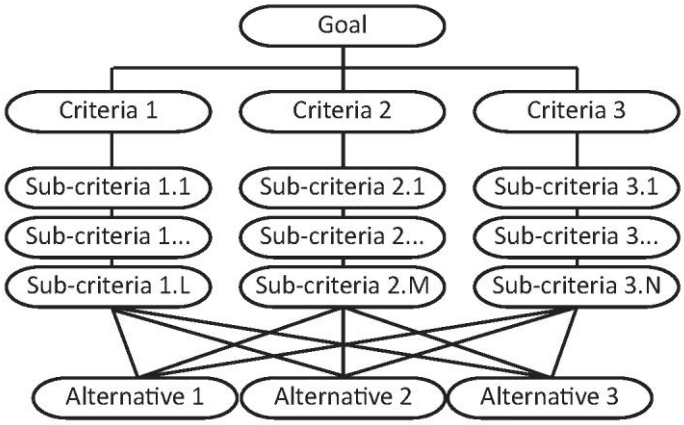


Figure 19 Hierarchical structure used in AHP with goal, criteria, sub-criteria and alternatives (Bhushan and Rai, 2004).

When using direct weighting methods, the stakeholders compare and weight the sub-criteria by, for example, dividing 100 points among the sub-criteria (Pöyhönen and Hämäläinen, 2001). A study in South Africa compared the outcome of the AHP with direct weighting approaches. Although both weighting procedures generate similar results, stakeholders reported to feel more comfortable with doing comparisons as required by the AHP method (Brent et al., 2005).

5 Learning from Cases

5.1 Factors of Failure

This chapter summarizes a literature review of scientific papers describing solid waste management situations in low- and middle income countries. The papers selected, all provide reference to causes of deficiencies or reasons for failure in the solid waste management systems.

Guerrero (in press) recently conducted a systematic study related to waste management in developing countries, analyzing literature from 2005 to 2011 from two scientific journals. The aim was to: a) establish stakeholders and how their activities influence the elements of the city's waste management system and b) describe the technical, environmental, socio cultural, legal, institutional and economic factors which enable the system to function or not to function (Guerrero et al., in press). The results show that few articles give quantitative information on the cause-effect relationship. The qualitative results obtained were structured along the ISWM framework which distinguishes stakeholders, waste elements and influencing aspects (Van de Klundert and Anschütz, 2001). Using the work of Guerrero as a starting point, this chapter structures the same information in a more condensed way to highlight the factors of failure as mentioned in literature, categorizing them under the topics:

- technical, (relates to infrastructure and equipment)
- organizational (relates to management, skills, and motivation as well as staffing)
- network and integration (relates to integration of all stakeholder and service providers into the system)
- financial (relates to all aspects of revenues and funding to cover costs of service)
- legal, policies and politics (relates to policies, enforcement of rules, and politics)
- public awareness and participation (relates to population growth, public awareness and perception as well as collaboration of the public)

The Table 13 below shows the summarized outcome of the literature review, focused on scientific publications accessible to the author through SCOPUS. All referenced publications contain information on causes of local deficiencies in solid waste management. The country and reference list is not comprehensive as the objective was to give an overall qualitative indication of causes mentioned – some more frequently than others. Additional references referring to no specific country but rather to the "global developing country context" were also included in the list to show what the respective authors interpret as overall significant causes of deficiencies.

It must however be emphasized that for certain factors mentioned, the waste manager has little power or control (e.g. population growth, settlement patterns, legislation, policies, politics) so there is little scope for the waste manager to improve in that respect.

Table 13 Overview of mentioned factors hindering solid waste management performance, sorted alphabetically by country.

Country	Main factors causing deficiencies in solid waste management								References
	Rapid population growth and changing lifestyles	Lack of public awareness and collaboration	Weak legislative framework, and weak enforcement	Fragmented inefficient organizational structures	Inappropriate or insufficient equipment and infrastructure	Lack of finances or inefficient revenue collection	lack of human resources or weak capacity or motivation of staff	Lacking data (monitoring) & control which leads to lack in planning	
Global						✓	✓		(Collivignarelli et al., 2007)
			✓				✓	✓	(Diaz et al., 2007)
							✓	✓	(Fricke et al., 2007)
		✓		✓	✓	✓	✓		(Zurbrügg et al., 2007b)
		✓					✓		(Diaz, 2009)
	✓	✓			✓	✓	✓		(Shekdar, 2009)
		✓	✓	✓		✓	✓		(Troschinetz and Mihelcic, 2009)
			✓		✓				(Ali, 2010)
	✓					✓	✓		(Guerrero et al., in press)
Bangladesh	✓			✓		✓	✓		(Ahmed and Ali, 2006)
Botswana							✓		(Bolaane, 2006)
Brazil						✓			(Fricke et al., 2007)
Cameroon	✓		✓	✓					(Manga, 2007)
					✓				(Parrot et al., 2009)
Chile			✓	✓			✓	✓	(Hüttener and Zurita, 2007)
Egypt			✓	✓		✓			(Collivignarelli et al., 2007)
					✓	✓	✓	✓	(Sherif, 2007)
						✓	✓		(Abdrabo, 2008)
Ethiopia			✓		✓		✓	✓	(Esan and Wenborn, 2007)
Ghana				✓		✓	✓		(Post, 1999)
Guatemala				✓		✓	✓		(Zarate et al., 2008)
India				✓			✓		(Ahmed and Jamwal, 2000)
							✓		(Rathi, 2006)
	✓				✓				(Chattopadhyay et al., 2009)

Country	Main factors causing deficiencies in solid waste management								References
	Rapid population growth and changing lifestyles	Lack of public awareness and collaboration	Weak legislative framework, and weak enforcement	Fragmented inefficient organizational structures	Inappropriate or insufficient equipment and infrastructure	Lack of finances or inefficient revenue collection	lack of human resources or weak capacity or motivation of staff	Lacking data (monitoring) & control which leads to lack in planning	
India					✓	✓	✓		(Kumar et al., 2009)
(continued)	✓				✓				(Pattnaik and Reddy, 2010)
	✓			✓	✓				(Unnikrishnan and Singh, 2010)
Indonesia			✓	✓			✓		(Pasang et al., 2007)
Iran	✓	✓			✓	✓	✓		(Alavi Moghadam et al., 2009)
Kenya					✓	✓			(Henry et al., 2006)
Philippines			✓			✓	✓		(Paul et al., 2012)
Peru		✓				✓		✓	(Gamarra and Salhofer, 2007)
Jordan						✓			(Abu Qdais, 2007)
Mexico	✓					✓	✓		(Read, 2003)
Mozambique		✓		✓	✓	✓	✓		(Hunger and Stretz, 2007)
Nepal						✓			(Alam et al., 2007)
Nigeria	✓	✓	✓		✓	✓	✓		(Agunwamba et al., 1998)
			✓	✓	✓	✓	✓		(Imam et al., 2008)
	✓	✓			✓	✓	✓		(Ezeah and Roberts, 2012)
Pakistan		✓		✓					(Batool and Ch, 2009)
Palestine		✓							(Al-Khatib et al., 2007)
South Africa						✓	✓		(Couth and Trois, 2010)
Sri Lanka			✓		✓	✓	✓		(Vidanaarachchi et al., 2006)
Tanzania	✓			✓	✓	✓	✓		(Yhdego et al., 1992)
		✓							(Kassim and Ali, 2006)
Uganda			✓	✓	✓	✓	✓		(Okot-Okumu and Nyenje, 2011)

The two most frequent barriers mentioned, are the “limited financial resources” and the “lack of human resources or weak capacity/motivation of the staff” inside the organization (typically this is the solid waste management department of the municipality). These two factors are intricately linked to one another.

What can be achieved with a certain budget, in terms of service quality and coverage, depends on the manner in which these funds are used. “Inefficient operations” consume a large part of the budget without contributing to service quality. Cost efficiency is unfortunately often not an objective pursued by the municipal authorities. This is especially true when politicians allocate budgets to the solid waste department. By proving that only little can be achieved with the funds available one may actually solicit more money from the central municipal or government budget. Introducing user charges might be seen as an option to improve cash flow and to enhance accountability for service performance. However, unsatisfactory service provision or even a lack of trust in service quality directly affects residents’ willingness to pay and so again threatens the financial budget. Figure 20 below shows, for the generic case of tariff based systems, how low service quality (inefficiency) creates a vicious circle of decreasing funds which further hinder service provision (Zurbrügg et al., 2007a).

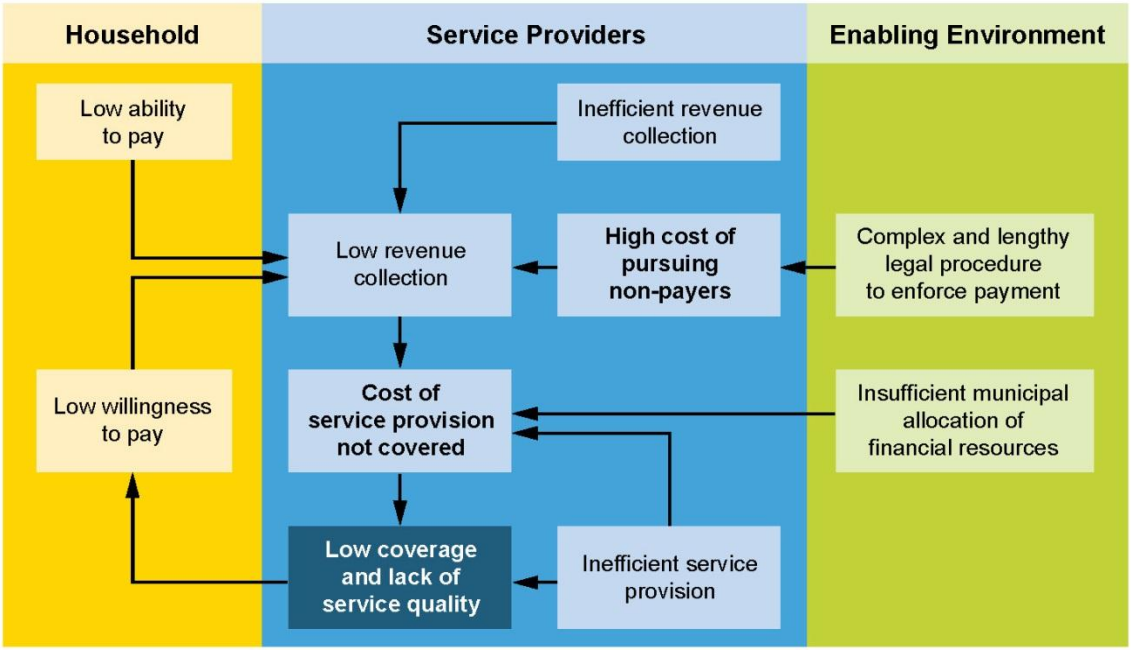


Figure 20 The vicious circle of decreasing funds which hinder service provision, (Zurbrügg et al., 2007a)

The intricate web of cause effects are depicted in Figure 21. Lacking skills and knowledge at technical level may lead to bad choices in technology. These are then either overly expensive or even inadequate to provide the expected service. This bad choice prompts a new need for investment capital which is part of the capital expenditure (CAPEX) budget. Furthermore, the lack of technical skills will diminish the chance of professional maintenance of equipment and infrastructure. This leads to frequent breakdowns or long downtimes, or even a reduced lifespan of equipment and infrastructure. All this decrease service efficiency and performance and thereby increase unit cost of service, or said in other terms , increases the overall operational

expenditures (OPEX). Low worker morale and low job status also affects the performance and motivation of staff to work efficiently.

“Lack of appropriate equipment”, or quantity of equipment, is also a barrier frequently mentioned. Most often this relates to the fleet of collection and transport vehicles but may also include design or number of collection bins and/or transfer stations.

In many low-income countries, specific regulations for solid waste management are lacking (Terazono et al., 2005). In other countries where regulations are available, they mainly assign responsibility and expectations to stakeholders, which is most often the municipality. It is however very difficult to penalize municipalities that fail to comply to regulations (Shekdar, 2009). Under such circumstances there is limited requirement for accountability by the municipality for the services they provide. This again does not help enhance efficiency.

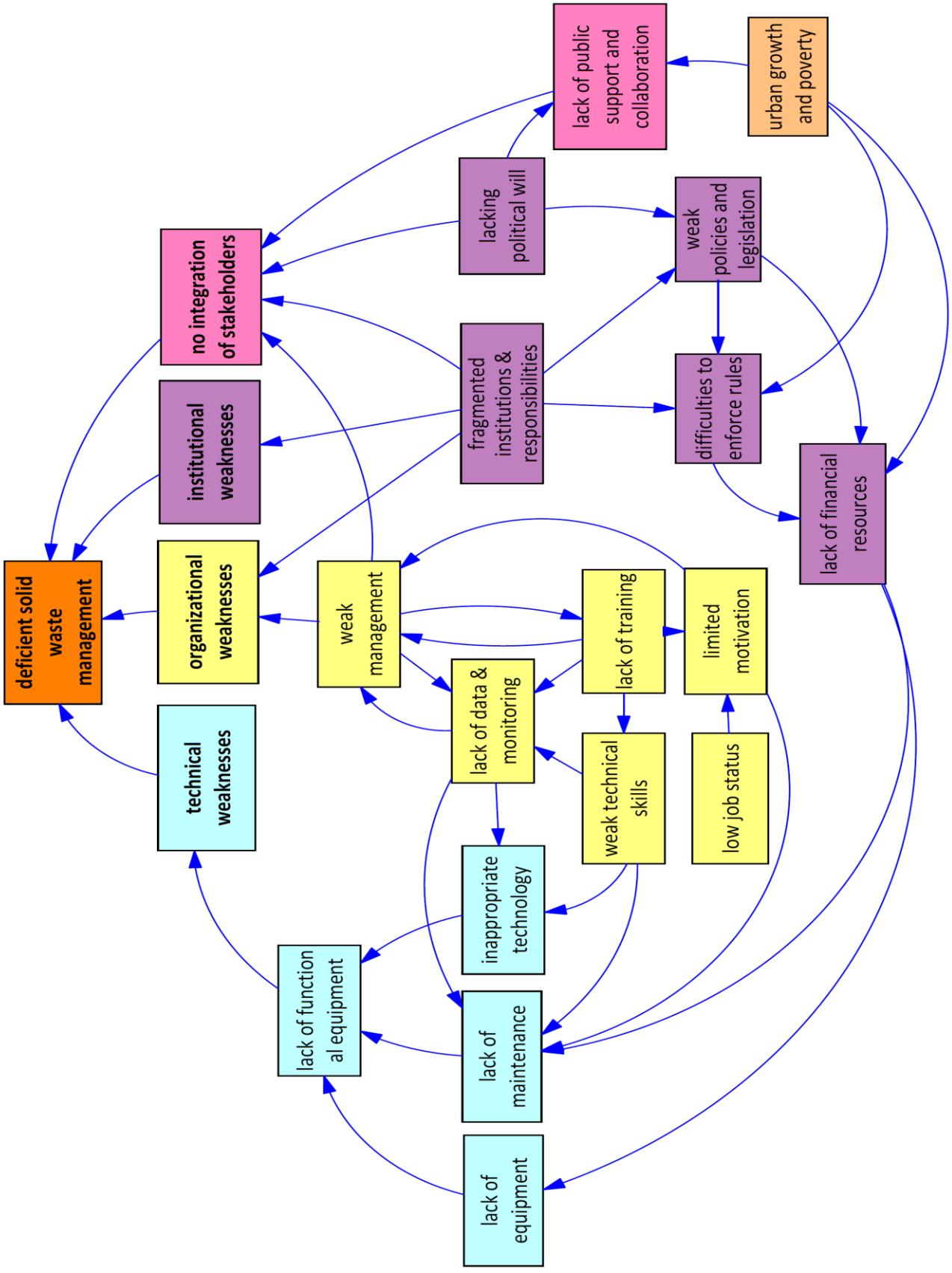


Figure 21 Cause-effect relationship for deficient urban solid waste management services.

5.2 Factors of Success

This chapter derives from the previous chapter 5.1 as well as the literature study of identified sustainability aspects as described more in detail in chapter 4.6.3. The assumption is that if the reasons of failure can be mitigated, then in consequence the projects should show to be more successful and sustainable. Such success cases - often called "best" or "good" practices – are believed to represent an effective and sustainable way of delivering a particular project outcome and can used as demonstration and learning case for replication elsewhere. This chapter presents examples of cases which show promising signs of success. Rather than describing the cases in sequence however, this chapter is structured according to sustainability domains based on the concept of ISWM (Van de Klundert and Anschütz, 2001), the principles for sustainable and integrated solid waste management (Cointreau, 2001) and the elements of an enabling environment (Lüthi et al., 2011) as summarized in the one list below.

- *Supported by government and legislation*: The extent to which government endorses and supports the project and how it coincides with national laws, regulations, standards and codes.
- *Enabled through an effective organizational structure:* Which is clearly defined in its goals and objectives, has a strong forward looking leadership and operates under the principles of quality control, accountability, transparency, and equity. Here sound partnership with other solid waste stakeholders and networking is considered decisive to build on strengths and opportunities. In-house capacity to fulfill the quality of service envisaged is reflected by the skilled, motivated and continuously trained staff.
- *Embedded in a financially sound setup:* Involves a viable business model and business plan, access and the capacity to mobilize investment capital and mechanisms to recover capital and operational costs through reliable revenue sources.
- *Technically appropriate:* Where the project operates with locally proven technologies suited to the local context, ideally built in the region with local materials and skills, and with a reliable service chain to ensure rapid and effective maintenance and repair. Flexibility of the technology to cope with changing conditions is another feature of a suitable technology.
- *Environmentally sound:* Where project activities monitor emissions and comply with environmental regulations. Environmentally sound operations also strive to reduce energy and natural resource consumption, minimize emissions to water air and soil, avoid other nuisances, and safeguard workers and adjacent resident's health - independent of legislation.
- *Socio-culturally accepted and beneficial:* Involves the endorsement and support of the project by the community as well as their motivation and willingness to participate and contribute to the process and objectives of the project. This also comprises recognized and valued benefits for the community, not only in terms of improved cleanliness but also with regard to employment opportunities and local social and economic development.

The importance of these themes is illustrated with extracts from "best practices" obtained from literature and from 19 best practices identified during the ISSOWAMA

project (ISSOWAMA, 2010). As limited information is available from solid waste projects, well documented cases in the field of sanitation are also referred to, with the assumption that the same factors of success are relevant.

Institutional and legislative support

Given the nature of solid waste management as a public good, support by national and local authorities is a key requirement for any successfully project. In India, national legislation was adopted in 2000 with the "Municipal Solid Waste (Management & Handling) Rules" (Ministry of Environment and Forests, 2000). One section of this legislation necessitates "Urban Local Bodies" (i.e. local government) to stimulate and implement at-source waste segregation and then divert the organic fraction from the landfill and treat it appropriately. With this legal backing, citizens have means to force municipalities to take action (Zurbrügg et al., 2004). The composting project of Tikri in Delhi which processes market waste, was thus strongly supported by the municipal council as well as the Agriculture Produce Market Committee (APMC) and land was provided to the project proponent on a lease rent basis (ISSOWAMA, 2010). Another example is from the city of Mumbai where the municipal authority pro-actively supports citizens' waste management initiatives within the framework of a program called ''Advanced Locality Management'' (ALM). The city offers these initiatives a contact person for assistance as well as a regular forum with specialists and authorities. Here problems can be addressed and potential solutions are jointly elaborated (Zurbrügg et al., 2004). The national government of India also identified 100% sanitation as a goal for the 11th Five Year Plan [2007-2012]. This provoked national support to local city governments with financial assistance for state level strategies and city level plans, awareness generation and capacity building as well as legal support for initiating public private partnerships. The policy further envisages an annual rating scheme for all Class-I cities with annual awards to entice improvements (Ministry of Urban Development, 2010).

In Brazil, at municipal, state and national level "catador de material reciclável" (collector of recyclables) has been formally included as a profession in the Brazilian Occupation Classification (CBO). The local government of Belo Horizonte has legislation that includes the aspects of recycling, social inclusion, job creation and income generation as core elements of solid waste management. This paved the way for an integration of recycler cooperatives and recycling enterprises in the overall solid waste management plans through the lead of the "Public Cleansing Authority" (SLU) (Dias, 2011).

In the Philippines, the local government of Iloilo City recognized the potential of existing waste pickers and assisted in forming a Waste Workers Association which was then registered as a formal business enterprise. This set the stage for an effective recycling program well integrated into the formal solid waste management system (Paul et al., 2012).

In Mexico, the federal government declared the "crusade for a clean Mexico" in 2001, recognizing the current inefficient operations and assigning a clear role to SEMANAT,

the national ministry of environment, to intervene with support to local authorities in capacity development with targeted training programs (Wehenpohl, 2007).

In Pakistan, the case of a successful community-based sanitation project in the slum of Orangi-Karachi was possible, thanks to a major shift in policy by the municipal government in the 1970s to legalize the slum settlement. This gave people the opportunity to obtain titles to their homes. This again then fostered a sense of ownership, permanency and enhanced the motivation to invest (Khan, 1997).

Effective organizational setup and strong leadership

A clear organizational status is a precondition for sustainability. A strong leadership with a vision, clear functions of staff and their responsibilities, good employment conditions and prospects for career opportunities fosters staff motivation and commitment to the organization. One fundamental cause for strategic success in organizations has to do with people. In Peter Drucker's past work on management, innovation and leadership, he identifies "*innovation from creative people provides the only assured source of long-term success and competitiveness, because every other aspect of an organization can be duplicated by others*" (Balanced Scorecard Institute, 2002). Hiring the appropriate people, providing training and mentorship and fostering a continuous and endless learning process is considered crucial for any healthy organization. Commitment of staff can be evidenced by a proper execution of assigned tasks, but also by the fact that staff take initiatives to prevent problems or develop new ideas and opportunities. Four traits of robust and resilient organizational systems, focus on the human involvement within organizations and can be defined as: (1) flexibility, (2) motivation, (3) perseverance and (4) optimism (Bhamra et al., 2011). Leadership, which embodies these traits and complements them with the characteristics of: (a) well networked, (b) high quality standards, and (c) a strive for continuous improvement provides the ideal basis for an organization delivering a sustainable service provision.

Strong leadership can be recognized in many successful projects in water, sanitation and solid waste management. At the head of the well documented and successful Orangi-Sanitation project and the involved NGO OPP, which provided low-cost sanitation to a large urban slum in Karachi, was a charismatic dynamic and innovative leader, Dr Akhtar Hameed Khan (Hasan, 2006). His experience with participatory methods in his previous work with farmer cooperatives was fundamental for gaining trust and ensuring collaboration with the urban residents. On the hand, his appointment as researcher and professor at Michigan State University (USA), Pakistan Academy of Rural Development and Victoria College in Bangladesh, fostered his interest towards research and development and technical innovation (Khan, 1997; Hasan, 2002). This interest in research on low-cost innovative technologies and the conviction that with training and participation the residents can help themselves, provided the basis for the successful project. Replication of the Orangi model by other organizations, in other parts of the country, however, often failed (Zaidi, 2001). Although different factors were the cause, the aspect of strong leadership, which is difficult to replicate, certainly contributed to the difficulties in replicating the success.

Frequently, private sector involvement in solid waste management services is used synonymously to an understanding of improved organizational setup. Typically, private sector shows an entrepreneurial spirit, adherence to commercial principles and greater attention to customer satisfaction (Cointreau-Levine, 2000). The private sector has shown that it can more easily provide a more efficient or cost-effective service through simpler procurement regulations, easier access to capital through the financial market, and easier access to skilled and competent staff by offering competitive salaries. Leadership in the private sector generally has more control over their workforce in terms of who and how the work should be done. Finally, private sector is also less restricted by bureaucratic procedures or influenced by politics. Private sector is however, not a determinant of sustainability. The same principles of effective organizational setup and leadership can also be pursued and achieved in community-based schemes or local authorities (Ali and Snell, 1999), although this is less frequently observed in practice. In primary waste collection schemes, the microenterprise approach shows to generally be more entrepreneurial when compared to community-based systems which often rely on voluntary work and are less diligent in book-keeping and ensuring efficiency (Pfammatter and Schertenleib, 1996).

In the Philippines, in Iloilo City, a Waste Workers Association was initiated and registered as a formal business enterprise. The association counts 240 members who endorse certain rules and agree to work within a team recovering materials from waste. Organized as a cooperative, they are empowered and continue to explore new options and innovations such as the recovery of alternative fuels for use in cement industry), production of compost from organics or handicrafts made out of used packaging materials (Paul et al., 2012).

In Thailand, the Wongpanit Group is a good example of a successful recycling business approach. Management and environmental procedures are standardized and the ISO 14001 certificate was obtained for quality control (ISSOWAMA, 2010). The Wongpanit recycling facility is also a good example of how organizational strength can be defined by the capacity and effectiveness to cooperate and communicate with the wide range of stakeholders in solid waste management including its customers. Wongpanit Group organizes awareness programs at community level to promote waste separation, contributes to employment in needy communities and strengthens links to other solid waste workers (such as existing small operators, municipal garbage collectors, and small waste purchasing units) by integrating them into their recycling program (ISSOWAMA, 2010).

In neighborhood waste collection schemes in India, the challenge of ensuring good relations and communication with the households and warranting their participation was considered a main challenge and - if effective - an important factor of success (Zurbrügg et al., 2004).

In Mozambique, a change of municipal leadership brought significant improvements to solid waste management. Openly acknowledging mistakes and weaknesses, a more efficient and professional executive team was given more power, radically changing the approach by taking pro-active ownership and initiative and making good use of

external technical assistance (Hunger and Stretz, 2007). This led to significant improvement in service.

A viable and financially feasible business approach

Whatever the project revenues - tariff payments by residents, tax money from government, income from sales of recyclables, or international payments for certified emission reduction (CERs) - the cost of operation and cost of capital (i.e. interest rates from loans for investments) must to be covered to ensure sustainability of any project. A sound business model in place, reliable budgeting and state-of-the-art accounting are all important prerequisites for monitoring and evaluating financial performance of the project.

Where municipal departments are in charge of services cost recovery is usually not an issue. Expenditures are covered through the overall municipal budget or national funding. Nevertheless restriction in budgets if not combined with more cost-efficient operations will invariably lead to no expansion in service coverage, minimum or no maintenance of equipment, no new equipment, and finally - in the long run - a decline in service performance.

In this regard, private sector services by their nature of having an obvious interest in profit, are considered to be more attentive to financial viability. Ramani (2012) demonstrates that the commonality of all progressive and successful sanitation entrepreneurs is their adoption of a market based approach (Ramani et al., 2012). In Chennai India, the French multinational Onyx obtained a municipal contract to collect waste and sweep streets in one zone of the city (Jayaraman, 2002). Through improved cost efficiency the cost per ton of waste collected diminished as compared to the previous expenses of the municipality. In Ghana, Zoomlion Ghana Ltd has established itself as a key service provider. Formed in 2006 with a few members of staff, Zoomlion has now grown to a business with core staff of about 2,800 managing 63,000 workers (Zoomlion Ghana Ltd, 2012).

As an alternative to large (often multinational) companies, also the local formal and informal private sector, microenterprises or small- and medium-enterprises (SME) can sustain a financial viable business of waste collection or recycling for a city neighborhood (Pfammatter and Schertenleib, 1996; Haan et al., 1998). Using a simple technology, and transporting the waste to the nearest collection point, they provide low cost services to households. A study in three Mexican cities shows that nearly 3,000 informal refuse collectors are collecting 353,000 tons of waste a year, earning up to five times the local minimum wage. They recover waste at household level or in the neighborhood and to do this they invest in collection vehicles – either pushcarts, donkey carts, horse carts, or pickup trucks (Medina, 2008). Similarly in Brazil, the cooperative COOPAMARE (Cooperativa de Catadores Autônomos de Papel, Aparas e Materiais Reprovitáveis), founded in São Paulo in 1989 now has 80 members along with about 200 independent waste pickers. It's members earn 300 USD a month, twice the minimum wage (Medina, 2008). Financial viability also does not seem to pose a

problem for the recycling facility of the Wongpanich group in Thailand. The sale of recyclables targets a well-established domestic market as well as international customers from the Lao PDR, Cambodia, Vietnam, Myanmar, The People's Republic of China, Taiwan, the Philippines and Malaysia. Currently franchise operations are also being negotiated in these countries for setting up local recycling plants (ISSOWAMA, 2010).

Appropriate technology

Experience shows that technologies and equipment which are already locally well-known have more chances to provide robust and sustainable functionality. This comprises availability of an existing service and supply chain for maintenance and spare parts as well as existing skills and local capacities to operate such technologies. Implementing technology innovation in the form of new equipment thus faces severe difficulties. This needs a well-designed prior training and support system before implementation. Developing adaptations of existing technologies to suit the required objectives of the solid waste project, is a more straightforward approach. Available guidelines for design and operation and standardized rules of construction can further indicate existing experience and a system of quality assurance.

In solid waste, the use of locally adapted vehicles for primary collection are frequently documented as good examples for appropriate technology (Pfammatter and Schertenleib, 1996; Coffey and Coad, 2010). Manually operated vehicles are developed, which can access the narrow and unpaved lanes of low-income neighborhoods. They need no fuel, can be locally produced and maintained, are simple in design and usually cheap. In Ecuador, locally developed tricycles equipped with a 1 m^3 box show to be well suited for garbage collection in slum areas through which motorized vehicles cannot easily pass (Stern et al., 1997).

In Egypt, composting has gone through a series of technical developments and modifications to adapt to local conditions. These modifications can be designed and manufactured in Egypt. The original approach was adapted to include manual labor-based sorting, open windrow composting with turning machines and sieving with vibrating and trommel screens (Sherif, 2007).

In India, the design and local construction of small scale anaerobic digesters by an enterprise and NGO, proved to fulfill requirements for well adapted technology. After building a large number of decentralized biogas plants on household, institutional and market level, the company has established a high level of expertise and can supply sound backstopping, and service for the existing facilities (Heeb, 2009). They provides construction and operational tutorial videos to train users of biogas digesters. Similarly in Cambodia, installation of biogas digesters went hand in hand with an intense training of staff on construction, operation and maintenance. This training was conducted by foreign experts from Sri Lanka with more knowledge than locally available. Furthermore, municipal staff was sent to work at a an existing biogas reactor in the region to practice construction and operation (ISSOWAMA, 2010).

In Bangladesh, simple and low cost technologies were introduced at the landfill which include gravity drainage of leachate and storm water to avoid reliance on energy supply (ISSOWAMA, 2010). Construction of safe and reliable working roads and disposal platforms ensured better working conditions and all-season functionality.

In Brazil, the established recycling cooperatives use simple handcarts to collect recyclable materials from commercial establishments and offices; for example in downtown Belo Horizonte. One cooperative - ASMARE – has established its own workshop where carts are constructed and repaired (Dias, 2011).

Environmentally sound

Solid waste management activities which emit pollutants to air, water and soil cause environmental impacts. Emissions are generally regulated by laws or standards, and in order to remain functional over long term any project must comply with these regulations. However, not all emissions are regulated by law, nevertheless they need careful consideration. For instance, measures have to be taken to reduce nuisances, such as noise, smell, dust - else the project may face complaints and strong public resistance.

In India, the composting plant of Tikri, identified the major potential pollutant emission to be the leachate from the compost windrows. To minimize environmental impact to groundwater and surface water, a compost pad was constructed which is lined with concrete and has a peripheral drain to collect any leachate generated during the process (or from rainfall). The collected leachate is then treated or recycled into the windrows to control their moisture content (ISSOWAMA, 2010). In the semi-aerobic landfill of Dhaka, Bangladesh, environmental emissions are duly assessed by surface water, ground water, leachate, soil and air quality sampling. The monitoring program was developed through a specific environmental management plan (ISSOWAMA, 2010).

From an environmental perspective, the amount and type of energy used in the project is seldom an decisive factor of success. An exception is when the energy source to operate the facility is scarce or not available 24/7. Incentives to make economical use of energy, or use renewable energy sources is typically driven by financial considerations.

Socially inclusive and accepted

Acceptance and satisfaction by customers and beneficiaries is an important feature of a well-functioning case. If the project can generate spin-off benefits for community, government or the public, then this will enhance overall support and thus strengthen sustainability of the project. Typical benefits for the community are employment opportunities. For governments these could be local, regional or national socio-economic development (e.g. tourism) or improved public health. Community involvement is essential where: (a) waste treatment facilities are sited, (b) for consultation on tariffs for cost recovery, or (c) when collaboration and public behavior is an essential element of the project (i.e. source segregation of organic waste).

In Porto Alegre, Brazil, the local government developed a partnership with a waste recycler association and fostered a close interaction with the civil society to ensure waste segregation at source. The outcome was an affordable integrated solid waste management system and an overall decrease in environmental pollution (Bortoleto and Hanaki, 2007).

Similarly, in Mumbai, India, a study shows that a system based on municipal services with community participation was able to decrease the cost per ton of waste by 20 % as compared to a system where the municipal service do not count on any community participation (Rathi, 2006).

In Bamako, Mali, intense interaction with the community in developing a neighborhood solid waste management system led to a new community organizational structure. This structure then served to educate community members, mobilized them and sparked new initiatives by identifying common priorities for further improvement of the neighborhood (Muller et al., 2002).

In Ghana, Zoomlion Ltd, the private contractor for solid waste management in many cities, has established a contract with the government to manage one module of the National Youth Employment Program. This program initiated by the government in 2006 tackles the high rate of unemployment among the youth of Ghana. Zoomlion integrates the recruited youth into the street sweeping services and desilting of drains. Provision of training and education is ensured and the company pre-finances their monthly allowances which is then reimbursed by the government on a quarterly basis. The program currently employs 22’700 staff in this program (Zoomlion Ghana Ltd, 2012).

6 An Alternative Assessment Approach

Following the analysis of sustainability domains, currently existing methods and tools for assessment, the typically identified factors of success in practice, and the framework of ISWM, this chapter describes a newly developed assessment tool based on a simplified questionnaire. The intended use of this assessment tool is for evaluating existing projects and cases and identified if and how they take the critical aspects which foster success into consideration.

The objectives of the tool is to assist its user to systematically analyze and evaluate solid waste management projects. Providing answers to a list of questions, will help grasp strengths and weaknesses of the project and capture if, and which main determinants of success are already considered and implemented. Assessing what has not been considered can moreover provide guidance on how the project can be adapted to enhance success and allow it to become a "best practice" case. The assessment method and questions are specific but nevertheless generic enough, to be useful for different waste management systems and projects. In addition, open questions allow the evaluator to describe certain aspects in more detail and elaborate on the sequence of project development over time and its future plans and perspectives.

The first steps in the development of this tool was conducted in the framework of a European community (FP7) funded project called ISSOWAMA (Integrated Sustainable Solid Waste Management in Asia). In workshops and moderated electronic exchange the consortium of 17 partners (of which 12 from Asia and 5 from Europe - the author was also one of the European partners) developed a first set of determinants for successful solid waste management projects. These were then particularized through a first draft set of questions. The first draft assessment tool was then tested by local researchers and solid waste specialists in their respective countries of the Asian region as one step of the ISSOWAMA project. Following the "testing", experts were solicited to give feedback on the usefulness of the assessment questionnaire and suggest changes. The author of this thesis then further developed the assessment questionnaire by application in selected solid waste case studies (see Part 3). The final revised version is presented below and as a template in Annex 4.

The assessment tool contains two sections.

1) In the first section the user is guided to describe the "case" to be assessed, in its goals and objectives including the functions and boundaries of the system that shall be evaluated.
2) The second section then is structured according to critical aspects namely:
   - *Supported by government and legislation (institutional and legislative aspects)*
   - *Enabled through an effective organizational structure (organizational aspects)*
   - *Embedded in a financially sound setup (financial and economic aspects)*
   - *Uses technically appropriate infrastructure and equipment (technical aspects)*
   - *Environmentally sound project (health and environmental aspects)*
   - *Socially inclusive, accepted and supported (social aspects)*

6.1 Section 1: Describing the Case to be Assessed

A) Describe the functions and elements of the case. Be specific on what "is" and what is "not" part of the assessment. There is no wrong or right way to decide on this, but it needs to be decided and made transparent. Ideally the boundaries of the assessment shall be limited to the specific activities of the organization or unit in charge of the case. This will later facilitate the assessment, especially in terms of financial aspects and organizational considerations.

Example: An assessment of a composting facility may or may not include the element of transportation (of raw waste to the facility, or compost away from the facility). If the composting facility buys or obtains the raw waste at the composting site (from a supplier, e.g. municipal waste collection trucks) then the element of transportation should not be included in the assessment. However if the composting facility has its own trucks and picks up the waste regularly from the vegetable market, then it should be included in the assessment as collection of waste is one part of the activity of the organizational unit.

B) Describe the goals and objectives of the case with regard to the service rendered or product developed. What is the design capacity of the facility? What types of waste does it manage?

Example: The main goal of a composting facility may be to produce compost from organic municipal waste for resale and reduce waste amounts in need for disposal. The facility may only receive organic market waste from the nearby vegetable market with a maximum design capacity of 15 tons per day

C) Describe existing competing activities of others.

Example: Organic waste may already be collected by pig farmers to feed their animals, or farmers may be using free chicken manure instead of compost.

D) List technology elements used in the case. Describe if there any specific environmental, occupational health or safety threats associated with these technologies?

Example: Again, for a composting facility this may be: composting pad with roof, air blowers and tubing for aeration, shovel loader, rotating trommel screen, bagging equipment, storage shed, office and sanitation facilities for workers, laboratory facilities with equipment, vehicles for marketing and transport, etc.

E) List and describe policies and legislation which exist in the country/province/city and concern waste management and the project (in support of or in opposition), as well as emission control and environmental protection. What are the specific rules, regulations and standards? What happens in practice; what are the processes and instruments for implementation of these policies and legislation; is legislation enforced?

Example: Aspects of ownership of waste, environmental emission standards, labor laws, workers safety rules, etc. In the case of composting, consider also rule and standards for compost quality and regulations for use of compost in agriculture.

F) List all the stakeholders of the project and their ties. This includes listing the type and number of beneficiaries (e.g. number of households, number of enterprises, etc.) which are served by this case. In a first instance this will comprise a quick overview of stakeholders, with some qualitative information on their roles, attitudes, perceptions, interest and influence. If a more detailed assessment is justified, then conduct a stakeholder analysis and social network analysis (see Chapter 4.4.1 and Annex 2).

G) Obtaining financial information with a breakdown on cost components is the next step in the description. Experience however shows that it is often difficult to obtain this data; especially financially successful case are often reluctant to share this information. Therefore this tool suggests to map a canvas of the business model (see Chapter 4.5.1 and Canvas Template in Annex 1)

6.2 Section 2: Assessing Critical Aspects

In this section a number of questions are asked which can be answered with ratings from 1 (no), 2 (rather no), 3 (rather yes), 4 (yes) and 0 (not applicable) based on the situtation at the time of assessment. It is however recommended to comment the reason for this rating. Furthermore, there is the additional possibility to respond to open questions which are structured to capture the change of situation over time as well as future plans and perspectives. Key questions in this regard are:

- How has this issue evolved over time (favorable or unfavorable)? How are the future perspectives in this regard? Is there anything the project team is doing to foster a future favorable development?

6.2.1 Institutional and Legislative Aspects

- Are adequate policies and legislation in place and implemented to support the operation and existence of the case?

- Does the case comply with environmental standards and regulations concerning emissions to the aquatic environments, soil and groundwater?

- Does the case comply with quality standards of service and/or product as defined by legislation, standards and regulations?

- Is the case endorsed by, and does it obtain support by local and national authorities? *This may also include unofficial (informal) endorsement, but in such cases a comment should be added why this remains unofficial. Furthermore the type of support (financial, political, in-kind, etc.) should briefly be described (e.g. tax exemptions, provision of land, etc.)*

6.2.2 Organizational Aspects

- Does the organization have a clear organizational status (formal or informal enterprise, NGO, CBO, cooperative)?

- Does the organization have a clear and viable business model and plan, independent of its organizational form or affiliation and manage the project with responsibility, accountability and transparency?

- Does the organization have dedicated talented leadership and dedicated skilled staff? *Attributes for dedication and skills comprise: technically competent, motivated, flexible, striving for high quality standards and continuous improvement, persevering, well networked, optimistic.*

- Do employee contracts attractive and conform or exceed to national and labor union recommendations (e.g. minimum salaries, work contracts, benefits, social security, insurance, etc.)? *This includes if the organization and its working arrangements take specific gender and child issues (of staff) into account. Furthermore regular skills development, training and education of staff by the organization as well as provision of career opportunities signals favorable staff working conditions*

- Does the organization interact successfully with other stakeholders in the system to structure and maintain a successful cooperation? *An important factor here is well-functioning collaboration with local authorities (e.g. the municipality) as the main responsible entity for solid waste management.*

- Does the organization maintain a data monitoring system or benchmarking to evaluate performance? *This includes if the organization solicits and addresses feedback from employees effectively.*

6.2.3 Financial and Economic Aspects

- Is accounting and regular financial analysis an important part of the organizations operations? *This includes if breakdown of cost components is available and if there is regular monitoring and evaluation of cost effectiveness.*

- Is cost recovery of the project (revenues) viable and sustainable? *Do revenues outweigh the cost? Are depreciation reserves to renew equipment available and capital costs/ repayment of loans ensured?*

- Does and can the project obtain access to capital (financial loans from different sources, e.g. banks, government, development agencies)?

6.2.4 Technical Aspects

Here the evaluator assesses the appropriateness of technologies used in the project The answers are required for the whole list technology elements used. Experience shows that if technologies/equipment are used which are locally produced and/or can locally be well maintained or operated (skills of operation and maintenance; availability of spare parts and workshops and repair equipment) then the technology can be considered more sustainable, flexible, durable, and robust.

- Is the technology appropriate and appropriately designed to operate under the local physical (e.g. climate, topography) and/or infrastructure conditions (e.g. roads, power supply)?

- Is there sufficient local availability of know-how and experience (skills) to design and build the technology? *Ideally construction would be possible with local available material resources.*

- Is there sufficient local availability of know-how and experience (skills) to operate the technology? *This includes it the employees/operators working with the technology been sufficiently trained?*

- Can the technology be maintained and repaired easily by the staff? *If not, is there an existing supply and service chain established that can do this timely and at an affordable cost?*

- Can the technology easily cope with and adapt to changing conditions (e.g. amounts or characteristics of waste)? *If the technology can easily be replicated and/or modularly up-scaled, this a sign of flexibility and adaptability.*

- Has the most cost effective technology been selected for the project? *This regards the cost of technology in relation to its life span and its handling capacity.*

6.2.5 Health and Environmental Aspects

- Does the case prevent nuisances like bad smell, dust, noise and insects/animals?

- Does the case safeguard workers' well-being and health? *This includes aspects such as: safety equipment provided (e.g. gloves, mask, closed shoes etc.), safety procedures developed and implemented, health status of workers' regularly checked, health care and treatment provided for workers if needed.*

- Does the case safeguard community well-being and health? *This involves preventive measures to minimize accidents and nuisance as well as plan of deployment of mitigation measures in the case of an event.*

- Does the case contribute to recovery and recycling of waste materials?

- Does the use make an effort to minimize use scarce natural resources or polluting energy sources? *Ideally the case recovers energy from waste to reduce its own consumption.*

6.2.6 Social Aspects

- Do beneficiaries (residents or local authorities) regard the case as socially beneficial and are they supportive to the project? *Was the case developed through a strong community or public demand and support?*

- Does the project empower local structures (development committees, user groups, consumer associations and elected representatives, etc.) and provide direct or indirect local employment opportunities?

- Does the project provide equitable service or products, which also addresses the needs and potentials of the most vulnerable and marginalized groups of society?

- Is community participation/involvement considered and implemented in the project? *Have beneficiaries been informed about their duties towards and their benefits from the case? Do beneficiaries have the possibilities to give feedback or to complain to the management?*

6.3 Prioritizing the Critical Aspects

A challenge of the above described question-based assessment tool is that all critical aspects are considered at equal level of priority. This most probably does not reflect reality. It will be the specific waste project scope - be it primary waste collection, composting, recycling and recovery centers or landfill management – and the local enabling (or disabling) environment which will determine the importance of each aspect. This research does not have the objective to qualify and rank the importance of each aspect but suggests that this process be conducted in future more systematically together with stakeholders and expert groups for specific projects. Based on the obtained results, hopefully, higher and lower priority topics can be detected.

One method of prioritizing and assigning weights to these critical aspects is by using the method of Analytical Hierarchy Process (AHP). A first step consists of arranging the hierarchical structure which in this case are the thematic domains on the first hierarchical level and the specific aspects on level below (Figure 22). Assigning relative weights to each criteria at each hierarchy level can be performed by pairwise comparison in a matrix. Based on the assigned values, relative weights are then calculated using computed eigenvalues and eigenvectors. The computations can be performed using spreadsheet software such as “Microsoft-Excel”, or else using a specialized decision-support software package such as “ExpertChoice”.

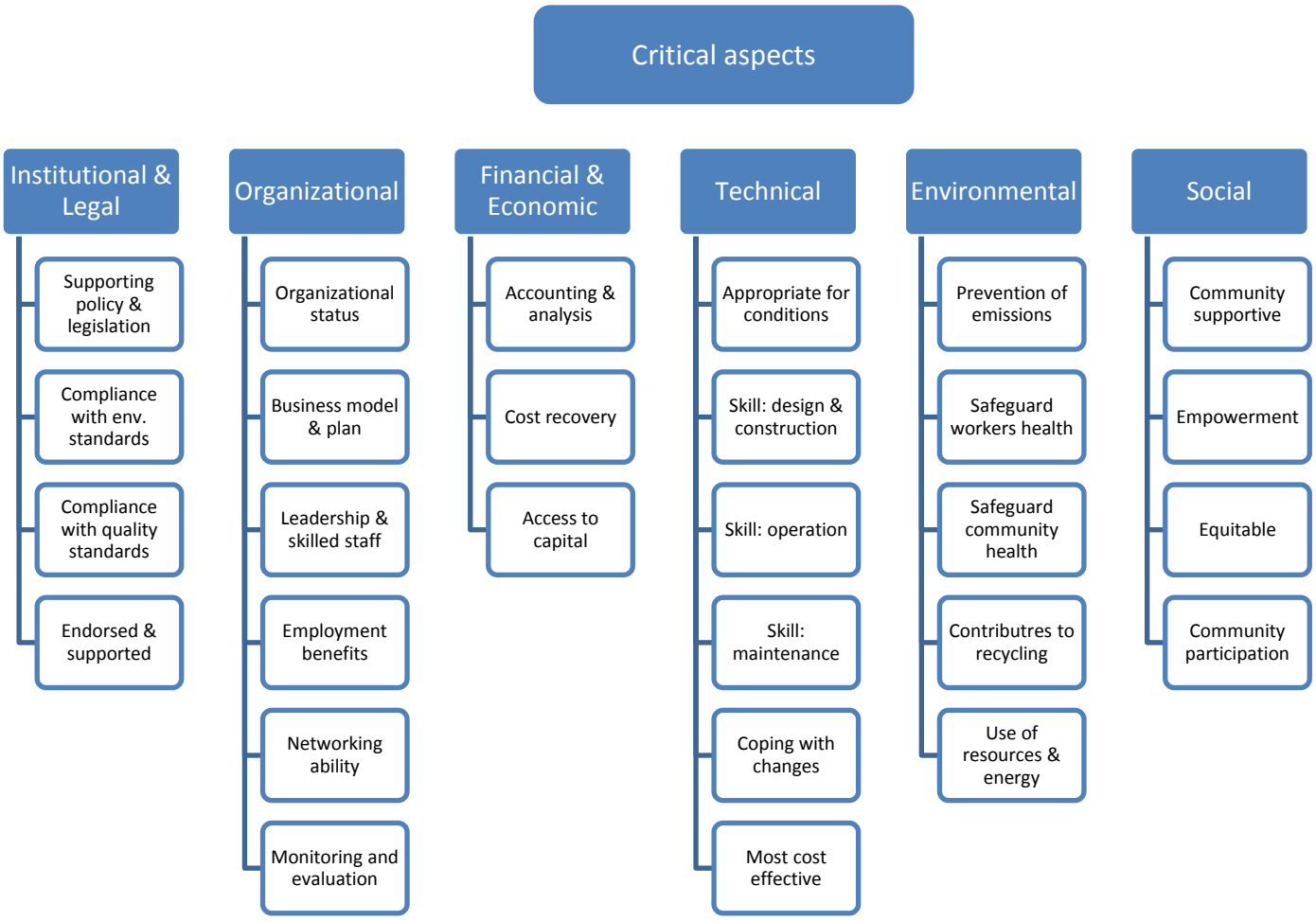


Figure 22 Hierarchical structure of the critical aspects

6.4 Assessing the Enabling Environment and Options

It is essential for any waste manager and decision-maker to keep abreast on the "enabling environment", monitor changes and evaluate who and what could be done to foster change in the environment in favor of the project or then adapt to it with project modifications. Understanding the context is especially relevant early in the project cycle between identification and appraisal - in order to make the right choices when developing strategies or planning investments. Most existing assessment methods target this phase, evaluating expected environmental and/or socio-cultural and socio-economic impacts in relation to available solution alternatives.

After studying selected assessment methods, the author proposes an "enabling environment" assessment approach based on the sanitation planning approach suggested by Lüthi, et al. (2011) and the ISWM assessment methodology (Anschütz et al., 2004). Integrated into this overall assessment approach, are selected tools which derive from existing methods of the different disciplinary sectors. Linked to the concept of feasibility assessment (Lohri, 2012) the tool proposes to evaluate:

- the enabling governmental and legal environment,
- the technology choices based on the principles of appropriateness,
- the social suitability assessed through stakeholder and social network analysis,
- the economic feasibility using methods of financial analysis, and
- the assessment of expected environmental emissions.

A stepwise guidance is proposed on how such assessments can be conducted and which tools are used at each stage of the process.

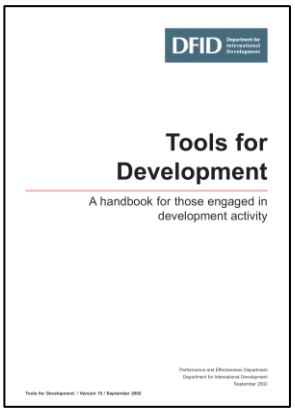
Preparing the Ground for an Assessment

Funding the assessment

This guidance assumes that funding is available to conduct the assessment. This includes among other: expenditures for workshops, stakeholder meetings, interviews and remuneration of local partners.

Defining the scope of the assessment

Be specific on what the assessment should entail. The specificity derives from a clear formulation of the problem. Problem tree analysis and subsequent objectives analysis are considered helpful methods to achieve this and documents describing the method and its use are available (DFID, 2002; Weiss et al., 2000) online. This guidance assumes that the problem relates to solid waste management. The scope will also define the boundaries of the assessment. This comprises the spatial area (neighbourhood or city?) and the sources and types of waste considered (healthcare waste, industrial waste, market waste?)



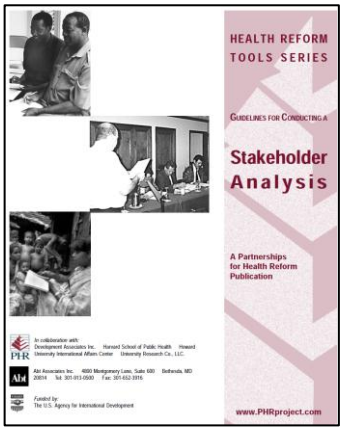
Identifying partners

To comprehend the local conditions and situation and potential developments, the assessment will have to rely on local expert information. A competent local partner with experience in waste matter will be a necessity especially if the assessment is instigated by a foreign organization or agency. When the lead is not with the municipal authority it is critical to involve them as early as possible.

Assessing Stakeholders

Understanding the context and local conditions must consider the perception, attitudes and roles of stakeholders. Stakeholders are all those who are affected by the project and/or affect the project. The basic questions here are:

- Who does what with waste and why?
- Who else is interested in waste and why?
- Who will lose and who will win from the proposed change and why?
- Who is the driver of the project and what are the reasons for the proposed change?



The method of stakeholder identification and analysis are well embedded in development work. The following documents are recommended for further guidance (DFID, 2002; Schmeer, 1999).

Part of the stakeholder analysis is to assess the relationship between stakeholders. This is called social network analysis (SNA). SNA aims at illuminating formal and informal relationships: 'who knows whom' and 'who shares with whom' (Ramalingam, 2006). It maps and measures relationships and flows of information and goods between people, groups, or organizations. Net-Map is a stakeholder network analysis tool designed to support projects by helping to understand, visualize, discuss, and improve situations where different actors influence the expected outcomes. The strength of "Influence Network Maps", is to allow individuals and groups clarify their own position and view of a context. The Net-Map community of practice maintains an useful website for obtaining information on how to use Net-Map and for sharing experiences (http://netmap.wordpress.com).

Assessing Waste System Elements

This comprises a description of the waste system elements - relevant to the scope and proposed project – as they are today and how they have developed over time. The time dimension, e.g. historical development, gives insight on the "process" of development and hopefully on vested interests of stakeholders in the past which potentially affect the future. Typical questions to answer are:

- What are the elements of the system? This includes: the sources of waste, household storage, household segregation, primary collection, collection point or transfer station, secondary collection, landfill/dump, treatment stations, recovery of recyclables (how and what?) at households, collection points, during collection and transport, at landfills/dumps, recyclables storage & processing

- What are the mass flows of waste materials through the system and between the elements?
- Who is in charge and responsible for the various activities undertaken in the waste stream (who does the work?)?
- What infrastructures and equipment are used in the different waste system elements?
- How much waste passes through the "unofficial" channels and how?

Depending on the scope of the assessment, different types (fractions?) of waste and their flow through the system will need to be assessed. Material flow analysis (MFA is a suitable method to systematically processing the information of mass flows as it is an analytical method of quantifying flows and stocks of materials or substances used and transformed in a well-defined system (Baccini and Brunner, 1991).

Assessing Institutional Structure & Legislative Support

Given the nature of solid waste management as a public good, any project will be influenced by governmental stakeholders. It is important to understand the current setup of roles, responsibilities of the different institutions and their capacities. Clear commitment within municipal government to support (if not lead) the project is one precondition for success. Questions to answer include:

- Is the project scope and area of focus in line with the national, regional and local governmental development plans, strategies and policies?
- How are decisions currently made in solid waste service provision and who is involved?
- Can and does the government promote alternative service delivery functions, such as the participation of the community or private sector?
- What waste laws, policies, standards, rules, and sanctioned financing mechanisms exist and how are these put into practice/enforced?
- To what degree would the intended project comply with these laws, policies, standards, rules, and financing mechanisms?
- What are the future prospects in policy and legislation development?
- What support would the government provide to the project (e.g. tax exemption, land, infrastructure)?

Typically different governmental authorities have overlapping mandates and responsibilities. Legislation which regulates the responsibilities of the different institutions and environmental protection will need to be studied carefully. Policies should also be considered which only link indirectly to solid waste management activities, such as urban development or energy supply.

Assessing Technical & Environmental Appropriateness

Assessment of technical feasibility identifies the risks of technology failure. It checks what the technologies proposed would require to remain functional and if these requirements can be met in the local context. It also identifies, for each proposed technical option, the expected emissions and potential impacts on the environment.

Having a clear and precise technology description is the first step in the process. These can be based on technical specifications or on "real cases" where these technologies are already in operation. The technical requirements of each option are then assessed in the project location. The information required derives from the principles of appropriate technology.

- Is the technology suited for the local physical conditions (climate, topography, temperature, distance) and is it designed to handle the waste type and amounts the project proposes to manage?
- Is the technology proposed proven elsewhere in the country?
- Can the technology design easily cope with changing conditions (types of waste and quality) and is the technology easily scalable (scaling up or down)?
- How frequent does the technology need maintenance and repairs?
- What type and what amounts of energy/fuel is needed to operate the technology and is energy or fuel needed 24/7 or sporadically? Check if these requirements can be met in the project location.
- How much land (of what kind) and water (of what quality) is required for the technology? Check if it is feasible to ensure this in the project location.
- What skills sets of the labor are needed to design, build, operate and maintain the technology? Are such skill sets available in the country or region and how feasible is it that they can become involved in the project? If not are there feasible ways to develop these skill sets?
- What support companies are needed to ensure technical performance (construction, maintenance work, spare parts supply)? Are these available in the reasonable proximity?
- What environmental emissions and nuisances are expected by the technology? Does the technology these fulfill the national environmental laws and regulations and meet international emission standards? Could nuisances be acceptable to the population/residents affected?

Land requirements may be in terms of space (m^2), but also comprise requirements such as slope, soil conditions, groundwater level, distance required to residential areas, access roads or water supply?

Assessing Financial Appropriateness

Access to capital and cost recovery are two essential elements of any project. Access to capital is often ensured for development projects, either by government development funds, development bank loans, or grants from NGOs or multilateral development agencies. More acute, is ensuring a regular and stable revenue stream to cover recurring costs of operation and maintenance. A financial feasibility assessment of the proposed project, and of each of its alternatives is therefore essential.

Net Present Value calculations are recommended at this step. This calculates the net financial benefit for every year of the project (present and future). If the NPV is positive then it means a return on investment (Chapter 4.3.2). Such a calculation however, requires an estimate of investment cost as well as the recurring yearly expected expenditures and the yearly expected revenues.

Questions to answer will include:

- Does the project have a clear and viable business model and plan, independent of its organizational form or affiliation?
- What is the expected unit cost of service or unit production cost?
- Who are the beneficiaries/customers for the service/product?
- How large is the customer group share and how much of the service/product can be sold?
- What are people already paying for comparable services/products and how does it compare to the estimated cost of service/product?
- Can other sources of revenues be generated (CERs)?
- Can capital be (easily) accessed?

Assessing Organizational Capacity

This step comprises an evaluation of the organizational structure which shall operate the proposed project. If an organization has already been identified then assess if the organizational status is recognized and the organization is legally allowed to manage and operate the solid waste project.

A further element is leadership. Leadership qualities include: technically competent, motivated, committed, flexible, innovative, persevering, optimistic, well networked, intent in pursuing high quality standards, and striving for continuous improvement.

Summarizing the Assessment

With all this information at hand a summary report can be finalized. Multi-criteria decision analysis would be helpful at this stage to sort or classify the alternatives based on a set of preferences. Experience however shows, that setting the preferences is often very demanding and complex in the development context. The author proposes further research to explore and develop simplified tools, possibly based on Analytical Hierarchy Process, to assist decision makers in this regard. Lohri (2012) proposes a system of “red flags” when information obtained in the assessment contradicts with the critical aspects required (based on the analysis of success factor from the previous chapters). A red flag indicates: Attention this is a potential pit fall! The project team would then be required to addressed this issue and see if and how it could be rectified before proceeding with the project cycle.

PART 3

7 Case study: Waste Composting in Gianyar, Bali

A shortened and adapted version of case study analysis was published in *Waste Management.* The original article is attached in Annex 5:

Christian Zurbrügg, Margareth Gfrerer, Henki Ashadi, Werner Brenner, David Küper (2012). Determinants of sustainability in solid waste management – The Gianyar Waste Recovery Project in Indonesia. Waste Management, Volume 32, Issue 11, November 2012, Pages 2126-2133.

7.1 Introduction

Like many other developing nations, Indonesia also has to deal with major challenges in the field of solid waste management. Especially in the tourist destination of Bali, a tropical island with a population of approximately 3.9 million attracting annually over two million foreign tourists, pollution through indiscriminate dumping or dysfunctional management of solid waste leads to detrimental environmental impacts and public health threats. The situation also directly affects Bali's economy that is inherently linked to tourism and the amount of solid waste tourism generates. Tourists want to enjoy the Balinese pristine landscape and culture and not be disturbed visually or environmentally by mismanaged solid waste. Unfortunately, most waste is inappropriately managed and indiscriminately burned or dumped on unauthorised sites or into rivers. Concerned residents have launched campaigns to reduce the amount of garbage generated. A "Say No to Plastic" or "Bali Cantik Tanpa Plastic" initiative launched to reduce plastic waste was directed towards retailers in Ubud, a small town in the centre of the island. It offered affordable alternatives to plastic shopping bags and raised the awareness of customers about the plastic problem (Planet Mole – Indonesia in Focus, 2007). However, this commendable effort only targeted plastic, which amounts to only a small fraction of Bali's solid waste made up of more than 70 % biodegradable organic material (Medina, 2009).

The ambitious Indonesia law "Number 18 of 2008 Regarding Waste Management" (Republic of Indonesia, 2008) requires all 504 regions of Indonesia to have: "Integrated waste processing sites where collection, sorting, recycling, handling and final waste processing takes place". The final waste disposal must be in sanitary landfills. The same law also requires the avoidance of methane emissions from landfills. Although this law should be implemented by May 2013, the lack of funding and investment in waste management projects makes a timely implementation unlikely. Nevertheless, in three out of nine regions of the province of Bali sanitary landfills exist or are currently being

built. Investments are being made by the national Ministry of Public Works while the operating cost must be covered by the regional authorities.

The Gianyar Waste Recovery Project, is an initiative which focuses on the biodegradable organic waste, and provides a seemingly sustainable system for integrated sustainable solid waste management, comprising waste separation and subsequent composting of the organic fraction. An assessment of this project had two main objectives: (1) to test the usefulness of a simple assessment tool in application; (2) to verify if with the assessment tool the elements of best practices can be extracted and if these are well represented in the assessment questionnaire.

7.2 Methods and Materials

Assessment of the case study in Bali by the author relied on a guiding set of questions covering the different sustainability relevant thematic areas – which comprise: technology, social aspects, economy, institutions, and environment. The assessment questionnaire is based on a mix of qualitative and quantitative data requirements. The list of questions is summarized in Table 14. The site visit, interviews, assessments and analysis were conducted in a period of approximately one year. The method of inquiry and data collection combined a variety of research tools and methods.

- *Document analysis:* This comprised a systematic search for information, evidence or insight into documents directly or indirectly related to the project. In the case of the Gianyar composting unit, the assessment benefited from very comprehensive project documentation which was studied in detail.
- *Direct observations:* This involved a site visit of the composting facility and observation of the solid waste management situation in the surroundings.
- *Semi-structured interviews:* The author conducted semi-structured 2-3 hour interviews with three key informants and documented direct observations at the site. Interviewees were the initiator of the project, the chief technical officer and the marketing and communication specialist. About 4 months later, in the scope of the ISSOWAMA project, a local researcher of the University of Indonesia, Jakarta also visited the site and held a semi-structured interview with the initiator of the project. Data from both assessments were compared and did not differ significantly, which proves the reliability of the assessment. Another six months later the author conducted an unstructured interview with two consultants of a development bank that had just recently visited the site and talked with a few staff of the composting facility.
- *Historical and trend analysis:* were integrated as questions for the semi-structured interviews. This involved understanding the processes and events that led to a current situation or context, using methods such as historical narratives, timelines and time trend analysis.

Table 14 List of qualitative indicators and the respective questions in the assessment questionnaire

Technical functionality/appropriateness	
Indicator	Question as formulated in the questionnaire
Local skills for design and construction	Is there sufficient local availability of know-how and experience (skills) to design and build the technologies or equipment used in the case?
Local skills for operation and	Is there sufficient local availability of know-how and experience (skills) to operate

maintenance	and maintain the technologies or equipment used in the case?
Use of local materials	Is there sufficient local availability of material resources (supply of material and spare parts) for technologies or equipment used in the case?
Level of performance considering expected goals	Is the case and technology performing as it was designed to perform? - Does the real amount of collected/treated waste correspond to the amount that was planned in the project planning document? - Is the system mostly functional and in operation (e.g. down times are minimal)? - Are measures taken to make the system work according to its design?
Flexibility to changing conditions (adaptability)	Can the case and its technologies easily cope with changing conditions/context? - Is there sufficient availability or access to space and facilities to increase capacity? - Is there sufficient availability of facilities & equipment to adapt to a changing characteristic of the waste? - – Do other changing conditions provide a barrier to the case and if yes what measure are taken to overcome this?

Health and environmental impacts	
Indicator	Question as formulated in the questionnaire
Workers related protection and health care services	Does the case safeguard workers' well-being and health? - Is safety equipment and training provided to safeguard workers' health? - Are measures to safeguard health used by the workers? - Is health status of workers' regularly checked? - Is health care and treatment provided for workers if needed?
Community related health protection	Does the case safeguard community well-being and health? - Does the case take preventive measures to safeguard community health? - Do hardly any accidents/diseases occur in the communities which are related to the solid waste management case? - Are complaints minimal about any form of nuisance (noise, insects, rodents, malodors, etc.) caused by the case and are rectified through appropriate measures? - Is serious environmental pollution (which may directly influence health of the community) avoided through appropriate measures?
Compliance with environmental legislation	Does the case comply with local environmental standards and regulations concerning emissions to the atmosphere, aquatic environments, soil and groundwater?
Compliance with perceived limits of emissions	Does the case prevent nuisances like bad smell, noise and insects?
Efficiency of natural resource and energy consumption	How efficient is the use of scarce natural resources and polluting energy sources?
Effectiveness and limitations on waste generation	Does the case pay attention to minimize waste generation? (only relevant if the case both "generates" and "handles" wastes)

Costs, finances and economics	
Indicator	Question as formulated in the questionnaire
Level of cost efficiency	Does the case provide the service cost-efficiently
Level of cost recovery	Is cost recovery of the waste handling case functioning and sustainable? - Do revenues outweigh the cost of providing the service? - Are depreciation reserves to renew material/machines available? - Is the dependency on time limited funding support minimal? - Are beneficiaries of the service willing and able to pay the suggested tariffs to the case for the waste handling? - Are sources of public funding (tax money) available to the case and provided in the long term (if required)?

Social aspects	
Indicator	Question as formulated in the questionnaire
Level of social commitment	Have beneficiaries been informed about their duties towards and their benefits from the case?
Social acceptance/support	Are beneficiaries favorable to the case and support the case in different ways?
Institutional acceptance/support	Are authorities favorable to the case and support the case in different ways?
Level of social demand	Was the case developed through a strong community or public demand and support?
Level of social interaction	Do beneficiaries have the possibilities to give feedback or to complain to the management?
Level of social inclusion	Does the case take specific gender and child issues (of beneficiaries) into account? Does the case provide equitable service (also for the poor)?

Organizational strength and institutional support	
Indicator	Question as formulated in the questionnaire
Level of in-house staff skills and capacities	Have the employees, managers, operators working with the case/technology been sufficiently trained? - Are operators of the system trained to guarantee smooth operation? - Are employees trained to fix and maintain the equipment? - – Are managing staff of the case trained to guarantee smooth operation?
Level of influential leadership	Does the organization have a motivated, determined, technically competent and well connected (to experts, donors, government, politics) leadership?
Level of external knowledge sharing and exchange	Do the organization and its senior and management staff have links to knowledge centers and exchange to other specialists of the sector?
Level of organizational formality	Does the case study have a clear organizational and registered status (NGO, formal private enterprise, etc.)?
Level of employment standards	Do employee contracts conform to national and labor union recommendations (e.g. minimum salaries, work contracts, benefits, social security, insurance, etc.)
Performance and quality monitoring and evaluation	Is a monitoring system or benchmarking in place to evaluate performance of the case (audits, inspections)?
Level of interaction with staff and customers	Does the organization address feedback from beneficiaries or employees effectively?
Level of political support	Does the case avail of political support?
Level of institutional support	Does the case have a well-functioning collaboration with local authorities (e.g. the municipality)?

7.3 Description

The original project was launched in 2004 by the Rotary Club of Bali Ubud together with a local non-governmental organisation (NGO), Yayasan Bali Fokus. It started with a small pilot plant on a 400 m^2 surface area. The process of composting was tested and validated with different operational conditions before scaling it up to a larger material recovery facility. In 2008, the first phase of a larger material recovery facility with a daily waste processing capacity of 30 tons of waste was completed together with another local NGO, Yayasan Gelombang Udara Segar (GUS) (translates to: Wave of Fresh Air).

In the second half of 2009, the facility, was extended to handle 60 tons of waste per day, and became operational in January 2010. Two light steel roofed buildings, without walls, of 2,400 m^2 were constructed . One is used for composting the other for waste sorting, storage of finished compost and recyclable. The now 4,800 m^2 roofed facility allows processing of most waste collected in the Regency of Gianyar with its 500 000 inhabitants (Yayasan Pemilahan Sampah Temesi, 2009). In addition, an existing redundant 400 m^2 sized pilot plant building was converted into a theme park focusing on educating and raising awareness of schools, government officials, NGOs and other interested parties on topics of climate change, alternative energy and renewable resources as well as solid and liquid waste (Figure 24).

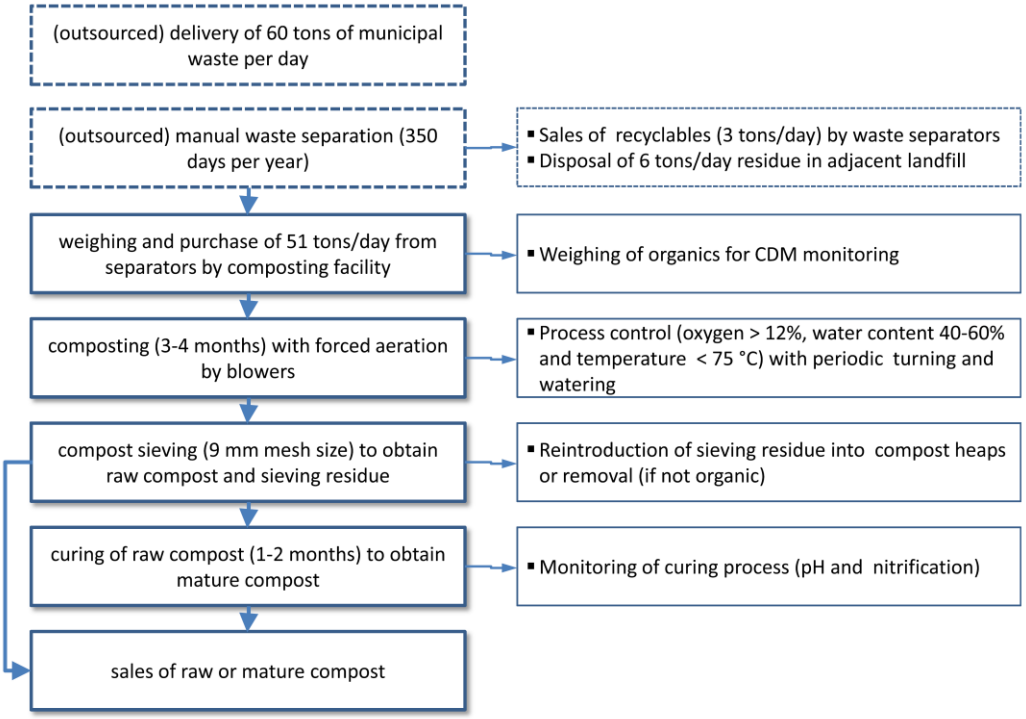


Figure 23 Flowstream chart of the Gianyar waste composting facility. Tons, times and percentages are estimates. (Yayasan Pemilahan Sampah Temesi, 2009)

The processing steps of the facility are described in Figure 23. The waste is delivered to a separation platform at the location of the composting facility by municipal waste collection trucks. The waste is then sorted by a subcontracted group of waste pickers.

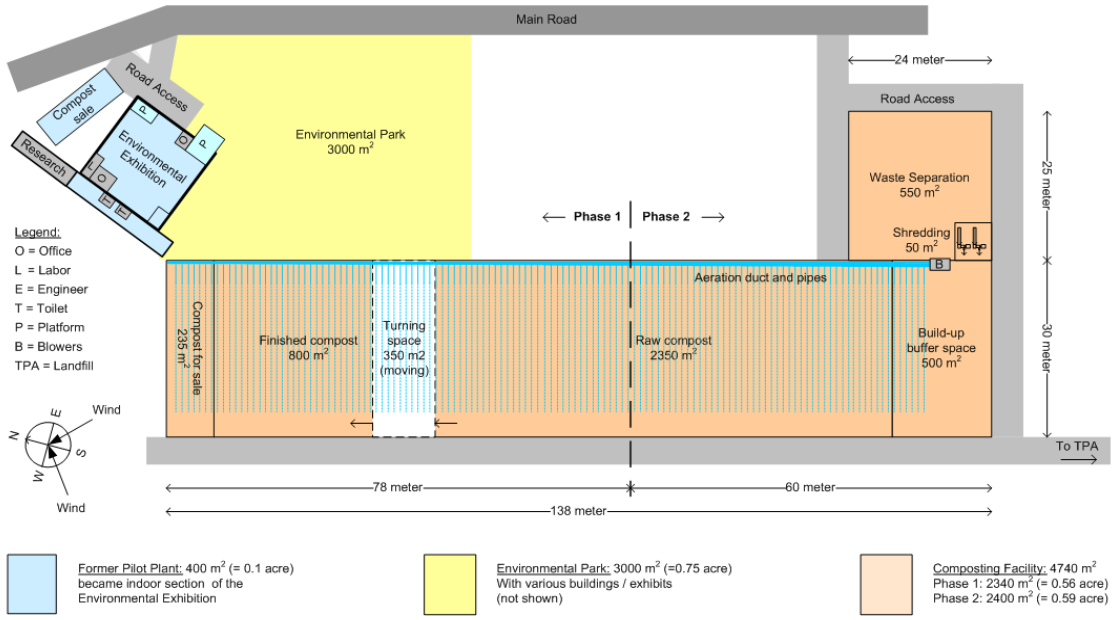


Figure 24 Layout of the composting facility Gianyar, source (Küper, 2011).

The biodegradable fraction of the waste amounts to an average of 83 %. Further 7% is non-organic waste of value which is recovered by the recyclers. The remaining 10 % of the collected waste is residue that is deposited in the neighbouring landfill after

hazardous material has been removed for separate save disposal (The Rotary Club of Bali Ubud, 2009). The waste collection and the outsourced manual separation were not part of the detailed assessment. The "boundaries" of assessment are thus limited to the composting process steps, the preparation for sale and the subsequent marketing of compost. Once the sorted organic waste is obtained from the waste pickers, it is heaped into trapezoidal windrows and subsequently force-aerated through the base of the windrow using blowers and tubes (Figure 25).

Figure 25 Composting windrows with forced aeration showing blowers and tubes, source (Küper, 2011).

The waste is composted with forced aeration for a period of 3–4 months. At this point some specific customers buy this non-mature compost. The other part is sieved and further matured for 1–2 months before the finished mature compost is sold.

7.4 Success and Sustainability Factors

The following chapters are structured according to the sustainability relevant thematic areas as listed in Table 14.

Technical Appropriateness

Use of local materials & local skills:
The Gianyar case makes a special effort to adhere to the principles of appropriate technology in design, construction and maintenance by considering local expertise and if feasible local available materials. Policy of the project is to purchase, if possible, only locally produced equipment. This has shown to reduce cost, facilitate procurement (import taxes, customs, etc.) and time delays with repairs or spare parts. It also allows easier local modifications and repairs which partly can be done by the staff of the facility or else by local mechanics and labourers.

Figure 26 Composting sieving at Gianyar, source (Küper, 2011).

Locally produced equipment and installations include:

- Turning of compost windrows: Currently the project does not have an optimal local solution for turning the windrows. Imported systems cost up to 500 000 USD and are not considered suitable. To-date turning is performed by an excavator which is on loan from the government. This creates a dependency which is considered a risk factor. The project management team is conducting negotiations to obtain a wheel loader which ideally will be made available by the Ministry of Public Works.
- Forced aeration system and monitoring: Consists of radial blowers and locally constructed cheap butterfly valves that regulate airflow for each table. A whole range of flow meters, temperature sensors and oxygen sensor tubes for monitoring of the process and for research are manufactured at the facility at a fraction of the cost of a commercial product.
- Sieving: A rotating drum sieve was constructed locally (Figure 26)
- Waste separation: Local custom is to squat while working and thus separation is carried out directly from the waste heaps deposited on the ground by the waste trucks. Conveyor belts have proven to be inefficient and were abandoned.

Technical elements still in development for which no local solution is yet available comprise:

- Shredding of organics: An improved and less energy consuming method of shredding organic waste prior to composting is being developed further by using vertical shredders and minimising abrasion of the shredder knives.

Level of local skills for design, operation and maintenance:

Although small composting projects have been implemented in Indonesia in the past and recently the city of Surabaya have initiated 14 small scale composting units (Reuters Video, 2012), there is no comparable composting facility in Indonesia similar to Gianyar in technology and scale. This means that local and regional experience is very limited and it is the project managers of Gianyar that are continuously learning from trial and error at their own site.

Level of performance considering the expected goals:
The performance of the facility is considered good. One ton of raw biodegradable waste produces 300 kg of sellable compost. Also in terms of compost quality the performance is good. The Indonesian National Standard SNI 19-7030-2004 (Badan Standardisasi Nasional, 2004) provides the specifications for compost from organic waste. Unlike other countries, Indonesia however does not restrict the use of the term "compost" for products of aerobic decomposition. The Gianyar compost product fulfils the Indonesian standards for all parameters (Table 2). Also the measured concentrations of heavy metals (not listed in Table 15) are far below the standards.

Table 15 Comparison between Indonesian standards for compost and the analysis results of compost from Gianyar composting facility (Badan Standardisasi Nasional, 2004).

Parameter	Unit	Indonesian compost standard	Gianyar compost
pH		6.8 – 7.5	7.1
C/N ratio		10 - 20	11.2
Organic matter	%	27 - 58	45.5
Nitrogen (N)	%	>0.4	2.4
Phosphorous (P_2O_5)	%	>0.1	1.1
Potassium (K_2O)	%	>0.2	1.1
Carbon	%	9.8 – 32.0	20.8
Fecal *Escherichia coli*	MPN/Gram[+]	1000	0

+ MPN: most probable number

Level of flexibility to changing conditions (adaptability):
The technology shows flexibility as it has continuously adapted to the increasing waste amounts delivered. The facility started with a small pilot unit processing only a few tons per day to a facility now composting 51 tons of organic waste per day.

Health and Environment

Level of workers related health protection and health care services:
The project pays particular attention to minimising exposure of employees to dust (fine particulate matter) which as described in many studies (Harrison, 2007) may contain a predominance of spores resulting in a respiratory tract illness with compost workers. At Gianyar all labour intensive tasks like separation and sieving are located upwind from the prevailing wind direction. Furthermore, dust is minimized by keeping the composing material sufficiently wet and hygiene masks are provided to workers. Sanitation and washing facilities are provided to all staff including the waste pickers. As the sorting process has been outsourced, the composting facility is no longer able to enforce health protection measures to waste pickers during the sorting process. Nevertheless gloves, hygiene masks and shoes are distributed to the workers sorting waste.

Level of community related health protection:
On community level there has been no incidence of health risk and nuisance. Community members are supportive of the project as it follows a period of uncontrolled dumping with severe impacts on the environment and the project has also rehabilitated the old disposal site. Waste recovery and composting at Gianyar reduces by 90 % the disposable waste volume. As disposal, under the responsibility of the municipality, is not yet practiced in a satisfactory way (open dumping), this high level of diversion is regarded as very beneficial to environment and health of the residents.

Compliance with environmental legislation:
The Gianyar project complies with the Indonesian law "Number 18 of 2008: Regarding Waste Management" (Republic of Indonesia, 2008). No leachate leaves the composting site and given the strict control to ensure sufficient aeration, odour emissions are not of concern. Proper control of the composting process through forced ventilation ensures aerobic conditions and avoids methane (a greenhouse gas) production and odour emissions. Since the organic fraction is responsible for the organic pollution of leachate and methane generation, a removal of biodegradable waste from the waste stream destined for landfill disposal also reduces the environmental emissions from the landfill. Finally, the benefits of compost application on soils are well documented in literature increasing their organic matter content, water retention capacity and nutrient content, and providing a protection layer from erosion (Rothenberger et al., 2006).

Efficiency of natural resource and energy consumption:
No detailed information was available regarding energy consumption. The energy sources used are mainly electricity for the blowers and sieves and diesel fuel for the excavator (wheel loader), shredder and small pick-up truck used for marketing activities.

Economic Aspects

Level of cost efficiency:
It proved difficult to estimate the degree of cost efficiency. Composting 51 tons of organic waste per day yields about 15 tons of compost per day. Based on the yearly balance sheet where expenditures are listed as 1794 Million IDR, this amounts to a cost per ton of compost of approximately 327'000 IDR per ton of compost produced (~36 USD/ton). As no other data from Indonesia is available, this figure cannot be judged. A small composting facility in Dhaka Bangladesh is cited with a production cost 19 USD/ton od compost (Rothenberger et al., 2006). This facility however processes only 3 tons/day and does not use forced aeration or any mechanized processes (no shredding no mechanized sieving). In comparison therefore the compost production cost of Gianyar results as fairly high. To optimise cost efficiency at the facility, aside from developing appropriate equipment, the separation process was reorganised and an outsourcing (subcontracting) approach was pursued. A self-organised group of waste pickers now separate the delivered waste. Recyclables are sold by the separator to local agents and middlemen, and the composting facility buys the biodegradable organic fraction from them at an agreed price per ton.

Table 16 Expected yearly cost/revenue statement for 2011

Accounting period 2011[a]	Million IDR[b]	Cost distribution %
Income		
Total compost sales revenues	1158	
Expenses		
Personnel cost for waste separation	576	32.1
Personnel cost for composting process	546	30.4
Diesel fuel	122	6.8
Electricity	48	2.7
Small tools and materials	72	4.0
Service of equipment	31	1.7
Administration and contributions to community	37	2.1
Sales and marketing costs	62	3.5
Depreciation costs	300	16.7
Total expenses	1794	100
Balance	-636	

[a] using estimates for October to December 2011 based on figures from September 2011.
[b] 1 USD equals to 9000 Indonesian Rupiah (IDR).

Level of cost recovery:
The initial investment capital of 150 000 USD to launch the project was obtained through grants. Expansion of the facility to a 60-ton plant was budgeted at approximately 180 000 USD. According to the business plan of Gianyar, the project will become sustainable and profitable from the sale of compost. However, this has yet to be proven as the sale of compost poses a challenge. The Gianyar compost is sold for Indonesian Rupiah (IDR) 1000/kg in 20 kg bags and for IDR 500/kg as bulk (1 USD = 9000 IDR). Selling to farmers proves very difficult as the government subsidizes chemical fertilizer up to a level of 92 %. Table 16 shows a balance sheet for the year 2011 with an annual loss of 636 million IDR. The project team is well aware of this critical situation and has increased its efforts and energy on boosting the sale of compost by penetrating existing markets and addressing new outlets. Landscapers, hotels, golf courses, and reclaimed land along the seaside are typical local bulk markets. The Gianyar team is confident that by 2013 they shall be able to sell the full production as:

- A current state company client has been identified that produces organic fertilizer pellets and can access to fertilizer subsidies.
- Land reclamation projects are ready for greening and require large quantities of compost.
- The golf courts of Bali cover an area of 200 hectares and progressively buy more bulk compost.
- The “Bali Clean & Green” program launched by the Governor of Bali targets the replacement of all chemical fertilizers by 2013. To achieve this will require more compost than is currently produced in Bali.

To further support the financial business plan, the Gianyar project pursued registration as a Clean Development Mechanism (CDM) project (CDM registration in 2008). During ten years, the aerobic composting shall reduce greenhouse gases by 153 000 tons CO_2-equivalents, whereof 72,000 of these are eligible for carbon credits and become

payable after verification. The fact that payments for carbon credits occur “after” verification implies that funding sources need to be obtained upfront before the carbon credits can be cashed in. The project is registered under the CDM methodology AMS-III.F. – Avoidance of methane production from biomass decay through composting, version 05 and the estimation of the baseline emissions for this methodology refer to III.G. Landfill Methane Recovery using the First Order Decay model (FOD).

Social Aspects

Social demand, commitment, acceptance and support:
The rather poor rural village of Temesi embraced the project as it clearly met the priority and demand of the village. Upon project implementation, the former disposal site of Temesi was restored and its environmental emissions reduced. Restoration of the problematic landfill was welcomed by the population and did not meet the usual resistance encountered when implementing waste projects. The village also benefited from the project as it provided about 150 new employment opportunities, particularly to the needy such as marginalised women.

Social interaction and inclusion:
The established theme park (Figure 27) to host, educate and create awareness for school children and other visitors is greatly appreciated by the community. Many community meetings were held during project implementation and still continue to date. The issues vary from general information exchange and debate sessions on project progress and development to strategy development and decision making – for instance when the project decides to subcontract more waste workers for waste sorting. All interactions with the community always include the leaders of the Temesi village and their support proved to be helpful in disseminating project information to the local communities of Temesi and minimising any potential social conflicts. Also the foundation board members fulfil a similar role by conveying information in a formal way and thus prevent the spreading of rumours and conflict. The local stakeholders therefore act as a bridge between the waste facility and the local community.

Figure 27 Environmental education center at the composting facility, source (Küper, 2011).

Organisation and Institutions

Level of in-house staff skills and capacities:
At project level, the staff is trained in quality and process control after introduction of the Quality Assurance System ISO 9000, which was a major endeavour in capacity building. The specifically drafted "Quality Manual and Operating Procedures" is available in Indonesian and used as a basis for training and continuing education. Individual research staff have benefited from special training in in-house microbiological analyses, proper use of monitoring equipment and laboratory analysis. Managerial training to facility staff is also provided. During the step-wise development of the project "research & learning" always remains was a fundamental objective of the project. Various joint research partnership projects with national and European universities were conducted to optimise the process and improve the quality of the final product while reducing its costs.

Level of influential leadership:
First experience with waste recovery projects in Bali were acquired from composting activities by Denpasar municipality (the main city of Bali) with local NGOs and from NGOs projects in 1995 on waste recovery from hotels (Medina, 2009). The initiative for a composting project in Ubud (located in the Regency of Gianyar) pursued by the Rotary Club of Bali Ubud, was subsequently implemented by an NGO, the Bali Fokus Foundation but systematically promoted and led by an extremely dedicated and motivated person regarded to be the "driving force" and leadership of the project. This is the same person that pushed forward with the now established Gianyar composting facility. He is still instrumental in all strategic activities of the Gianyar project, networks with government officials and interacts with investors in acquiring more capital or reporting on progress and performance. His interest in composting, the enthusiasm in optimising the management and composting processes with regard to quality of the final product while reducing its costs, and the unfailing commitment to the project are considered major factors to achieving enhanced performance and on-going success of this project.

Level of political and institutional support:
The Gianyar (local government authority) was involved in the project at an early stage and provided administrative and legal support including the required land for the facility. This support was clearly fostered by the initial project team using the pilot plant as demonstration unit to show that the approach actually works and has minimal negative environmental impacts. The Regency of Gianyar and a newly established village-based foundation, the Yayasan Pemilahan Sampah Temesi (Temesi Waste Separation Foundation), took over the project in December 2008 and now manages it on a public-private basis. This foundation, which is firmly anchored in the Temesi village where the facility is located, is embedded in the village administration. A "Memorandum of Understanding" (MoU) was signed between the village of Temesi as project host, the Regency of Gianyar and the Foundation. The Foundation board members maintain a valuable network, intensive exchange with institutions and also ensure continuing public relations with the residents of Temesi.

7.5 Conclusions and Outlook

Success factors of the Gianyar project:
The Gianyar project, comprising composting of the biodegradable waste, is a good example of a highly integrated approach accounting for the different elements of project sustainability. Attention was paid already during the planning stage to both technical appropriateness and to involving the local authorities (regency and village). This gradually led to a more comprehensive approach and finally to an organisational involvement of these institutional actors as well as a hand over of responsibilities to the respective entities. Technical appropriateness was not optimal from the start, and stills offers potential for improvement. However the assessment also revealed that the motivating factors to achieving improvement are on-going and continuous. Finding the necessary investment capital was not an easy task due to the limited "best practice" experiences required to convince prospective funders. Here it was the dedication of a "driving force" and strong leadership with his excellent network of contacts and abilities to advocate and convince people that certainly contributed decisively to project improvement and success. However, this issue might also be considered as a significant obstacle when planning for replication, as such individuals as main "driving forces" are not easily found and cannot be appointed but become involved for reasons of personal motivation, commitment and interest. A still open question and unresolved challenge relates to attaining cost recovery through good marketing strategy of the compost products. Obtaining governmental support for compost sales – for example through quality labelling and endorsement of compost by the Ministry of Agriculture – would be very helpful for compost sales. Another idea as practiced in Bangladesh could be to sell compost to a fertilizer company which has better means to distribute the product to farmers country wide through its network of agricultural extension services (Zurbrügg et al., 2005). Registering the project with the Clean Development Mechanism is helpful but unfeasible due to initial cash-flow problems, since credits granted after verification are low at the start and only increase over time (due to the "avoidance of methane production from biomass" method). Furthermore, the CDM registration under the UNFCCC is regrettably very burdensome and unaffordable for many projects, even if the project qualifies for "simplified modalities and procedures for small-scale project activities". In summary the low cost, low tech and low risk approach of this project is likely to act as a model for replication in Indonesia and other developing nations.

Value of the assessment tool:
The assessment conducted with an adapted version of the assessment questionnaire as developed by the ISSOWAMA project revealed that it is very helpful to structure data collection and analysis and to foster a more integrated assessment. Scope for improving the tool however has also been identified. The structure of the thematic fields should be revised to be more intuitive. On suggestions is to better distinguish the organisational aspects from the institutional and legal aspects (currently in the same thematic filed). On environmental emissions, the main criteria is conforming to the legal environmental requirements. Thus the long list of questions on emissions is not so helpful, considering that this data is very difficult to obtain. The questionnaire had only few questions on the enabling environment which influences performance and outcome of the project. Furthermore the study was not able to determine the relative

importance and contribution of each individual indicators to the success of the composting project. It is suggested that Analytical Hierarchy Process (AHP) should be explored as a method to involve stakeholder focus groups to determine weights of the indicators.

8 Case study: Primary Waste Collection in Managua

8.1 Introduction

The city of Managua in Nicaragua is the nation's capital with a population of about 2.2 Million. It is the main political, cultural, educational, commercial and industrial center of the country. Solid waste management of the city is the overall responsibility of the municipality, the "Alcadia de Managua" (ALMA). In charge is a sub-unit of the Dirección General de Infraestructura y Servicios Municipales (infrastructure and services) called Dirección de Limpieza Pública (public cleanliness). This unit is again divided into four departments, (i) household waste collection, (ii) non-household waste collection, (iii) landfill, and (iv) equipment maintenance. Next to these technical and support units of the municipality, the city is divided into 7 spatial and administrative districts. Each district level has a department of urban services under which there are sections of: (a) public cleanliness, (b) public works, (c) project formulation and evaluation, (d) cemetery administration, and if applicable (e) transfer station management.

The responsibilities of the Dirección de Limpieza Pública comprises organizing and conducting waste collection for the whole city, cleaning of drains, expanding service coverage to new settlements and managing the landfill and planning for new landfill sites. Waste collected in Managua amounts to 1400 t/day from 7 districts and 600 neighborhoods, of which 800 t/day is from households, 300 t/day from markets, hotels, shops (mall), industries and 300 t/day are collected as street litter or clean-up of creeks and illegal dumps. All this waste is transported to the main landfill of Chureca (Figure 28). A waste collection fleet of 77 vehicles (3 tractors and 74 compactors trucks of which in average 18 are at the workshop for maintenance), service the districts along the main (paved) roads (Toruño, 2012). This covers about 80% of Managua. The remaining 20% of the area cannot be accessed by these trucks given the either too narrow and unpaved roads or the low hanging electrical cables crossing the roads. In these areas the residents only have the option to either bring their waste to the nearest paved road, indiscriminately dump it onto unused land, into drainage channels and streams, or then use a primary collection service if available. It is such primary waste collection schemes, operated by cooperatives or small enterprises, that the municipality considers as an appropriate solution for improving waste collection service especially in low-income unregulated areas. With the support of development agencies and NGOs such waste collection initiatives were implemented in different districts including construction and operation of neighborhood transfer stations. Mr. Toruño , director of "Limpieza Pública" however reports that such activities currently only manage about 1.6 % of the total (Toruño, 2012).

This case study analyzes selected of primary collection projects in the city of Managua which considering their relative success can contribute to the learning on success and failure factors in solid waste management.

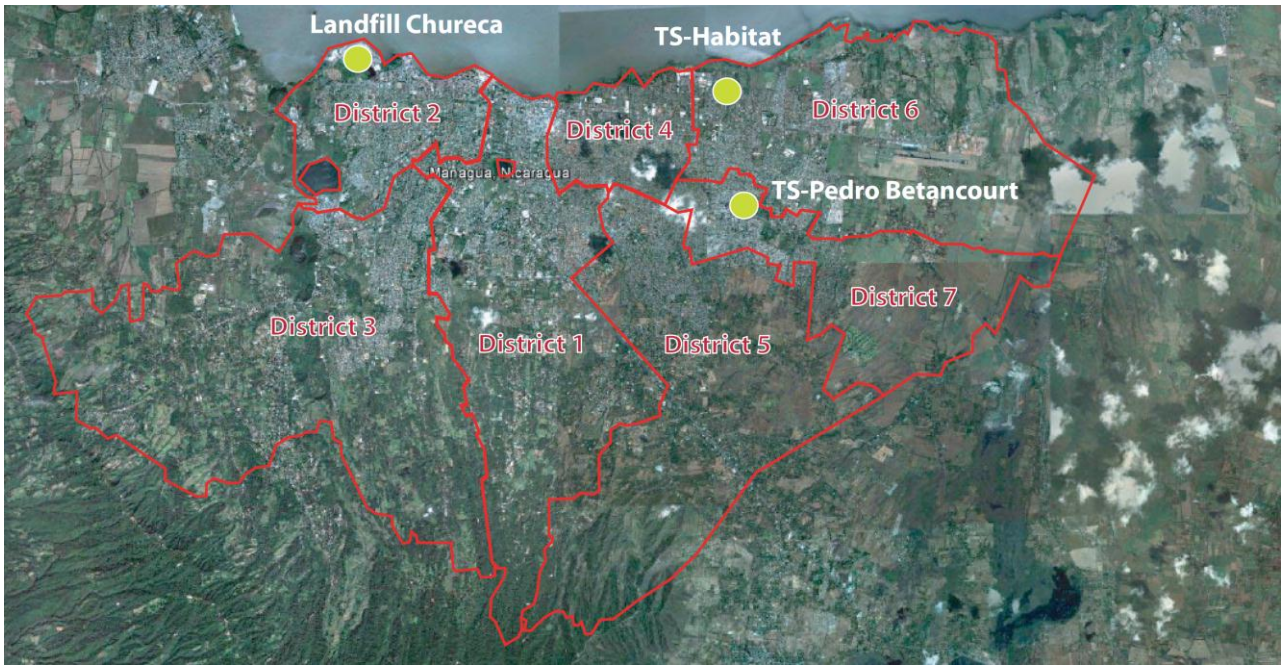


Figure 28 Seven districts of Managua, the city landfill and the approximate location of the transfer stations mentioned in the text, (base map Google Earth).

8.2 Methods and materials

The assessment was conducted with the help of the assessment tool as described in Chapter 6. During a field visit in 2012 the following methods were then used to gain detailed insight of the evaluated examples:

- Study of project documents, public documents of the municipality, project presentations and dissemination materials, as well as online magazine and newspaper research.
- direct observation at 6 specific locations in Managua: three transfer and recycling centers, the main landfill, and two cooperative centers.
- semi-structured interviews with: one leader of a waste collection cooperative, two microenterprise owners engaged in primary waste collection, one resident serviced by a primary collection enterprise, 5 project officers of various supporting agencies, one head of transfer station and the director of the department for municipal solid waste management services.
- three semi-structured group interviews, one with a community association (3 representatives), one with a waste collection cooperative (4 representatives present) and one with municipal staff at the transfer station (5 staff).

The preparation, site visit, interviews, assessments and analysis were conducted in a total period of approximately 3 months.

Description

Project RESSOC

The project RESSOC (with support of EU-funds and funds from the municipality) supports the development of total 6 cooperatives; 4 cooperatives of waste collection, 1 cooperative of recycling and 1 cooperative of bicycle recycling all located in district 7 of Managua. The support project is on-going and should end in December 2012. To-date all formalities to establish these cooperative have been finalized however the activities are not yet conducted as a cooperative. Currently the members of the cooperative already operate more or less as informal waste collectors/recyclers in the neighbourhoods. The steps in project development comprised: a) identified the existing informal sector, b) interacting with them to provide training and education and to help them form a cooperative. During the process some of the potential members "resigned" (by their own decision) or were screened out from the project due to lacking participation and/or commitment.

Organisational setup: The structure and organization form of a cooperative is promoted given the extensive experience of such systems in Nicaragua, and its concept of flat hierarchy without one strong person as leader. Experience however also shows that in some cases a few individuals are more influential and prominently voicing their opinions. From a "legal" point of view a cooperative must include at least 12 members. The structure of each cooperative consists of a directorate (1 president, 1 vice president, 1 secretary, 1 supervisor) and a supervising board (3-4 people). The project also has the intention of forming a "union of cooperatives" which shall facilitate communication to other stakeholders (ALMA or waste buyers) and thus strengthen the cooperative's position. However it is perceived that the cooperatives members have already been able to establish good personal links with the various stakeholders through the various events and workshops organized by the project, so the added value of the union of cooperatives remains disputed. The project is still pursuing negotiations with the municipality top obtain formal endorsement of the cooperatives.

One cooperative (CODESOL) of the RESSOC project was visited and three representatives were interviewed. CODESOL has been formalized and consists of 22 members. However it is not yet operational. Some members already provide services as informal groups or individuals collecting recycling waste. A group of members also act as waste dealer, buying from other recyclers storing the recyclables at their homes and periodically selling to large waste traders. Although developing a coop is a lengthy process costing a lot of money, it also involved a lot of meetings with people of the municipality (ALMA) which is considered very beneficial as close ties and personal relationships could be established. The members are already very familiar with collecting and managing recyclables but less with the regular waste collection service. They express their concern about the residents not wanting to pay for services. Their business plan foresees not only income from recyclables but also from the waste collection fees. Either one or the other cannot be omitted else the business would not be viable. One other major worry is that they will not have the capacity to service all households, especially after special, events when waste amounts are high.

Technology: Each waste collection cooperative will consist of about 2-3 vehicles (motorcycles-trucks) for waste collection. This equipment is typically used as neighbourhood taxis and is widespread throughout the city - predominantly a Indian brand. These vehicles can move along the unpaved and narrow roads of the neighbourhood and are not affected by the low-lying electric power lines which hinder transport by larger trucks. With about 2-3 vehicles per cooperative the service can cover one or more neighbourhoods (depending on size of neighbourhood). Usually one motorcycle-truck (collection vehicle) will consist of a team of three persons (1 driver, 1 collector, 1 assistant). Furthermore the cooperative will have 2 people allocated at the transfer station to sort recyclables. The project plans to foster source segregation of waste at household level, however the chances of success are questionable as the participation of residents is quite limited and it is already difficult enough to obtain payments for the collection service let alone engage them in separation. The waste collected shall be transported to the transfer station in the neighborhood of Pedro Betancourt (barrio Pedro Betancourt) of district 7 constructed with help of the Italian development agency. This transfer station is under the responsibility of the municipality (ALMA). It currently already serves 3 primary waste collection schemes (microenterprises) but should be enlarged to serve the 4 waste new collection schemes of the RESSOC project as well. Table 17 shows results of a SWOT analysis conducted for this project.

Table 17 SWOT analysis of the RESOC – cooperative waste collection project.

Strengths	**Opportunities**
• The project has set focus on training & education to learn the trade of recycling (segregating different materials) as well as entrepreneurship (accounting, etc.). • The members are well connected and maintain good networks to waste buyers and municipal staff.	• The skills acquired can provide opportunities to expand into other business and service sectors. • The project realizes that there are not high margins of profit in waste and members might leave to engage in other more profitable activities. From a project perspective this is acceptable as the goal to have fostered development was achieved.
Weaknesses	**Threats**
• The project main objective is social and economic development. Thus the focus on solving the waste problem is not the priority but just the means to an end. • The limited capacity of the current transfer station (TS) is a worry. Currently the TS is already working at maximum capacity servicing three microenterprises only.	• A threat voiced by the members is the attitude of the households. Littering is still common and residents still hesitate to pay fees for waste collection (30 Córdoba per month). • Waste service by municipal trucks (along the main paved roads) is free of charge.

Project Basmanagua

The project Basmanagua was a project supported by the Italian Development Agency in partnership with ALMA. The project was implemented by the NGOs Movimondo, Acra and Africa70 (Movimondo is now called RE.TE.ong) in District 7 of Managua. The Italian NGOs partnered with a local NGO in Managua called CAPRI which helped implement the project. The goal of the project was:

- Strengthening institutional systems (the municipality). The goal was achieved by links to an on-going project of UN-Habitat having the same objective.
- Creating awareness of population in collaboration with ALMA. This entailed developing a manual for trainer to conduct awareness raising campaigns and to strengthen what is called "environmental brigades". These brigades would also conduct "cleanliness days" to clean-up of neighbourhoods.
- CAPRI supported families with children working in recycling, in ensuring their schooling, school support, family support and support to the community.
- Economic component : which entails developing:
  - Credit fund to support microenterprises for waste collection and recycling.
  - Training and support of five such microenterprises. Three of these are currently operating.
  - Construction of a transfer station.

Table 19 shows results of a SWOT analysis conducted for this project.

Organisational and financial setup: The structure and organization forms promoted are microenterprises. Three microenterprises are currently operating, two of which were interviewed. The microenterprise *Limpiendo Bien* operates with two motorcycle-trucks Each vehicle has two staff (total of 4, which includes the owner and his wife). Service is provided to 300 household (hh) 3 times a week. This is not considered to be enough customers to break even and the microenterprise has plans to grow but is restricted by access to capital for an additional vehicle. The tariffs are 30 Cordoba per month per households (1 Cordoba = 0.041 USD). The microenterprise *Limpiendo Mehor* operates with only one motorcycle-truck but also 4 staff (Figure 29 – left): one driver, one worker, one supervisor (owner) and one person at the transfer station to sort and wash recyclables. This microenterprise serves 1000 households with daily waste collection. The tariffs are also 30 Cordoba per month/hh, but can also be paid on a daily basis (1 Cordoba per day). A rough financial estimate suggests monthly expenditures of 770 USD/month (580 USD personnel, 140 USD fuel, 50 USD repairs and maintenance). Based on this figure and revenues of 1.23 USD per household and month (excluding revenues for recyclables), to breakeven one vehicle would have to serve at least 630 households.

Figure 29 Microenterprise *Limpiendo Mehor* in District 7 of Managua (left) and primary collection vehicle of the municipality (UN-Habitat project)(right).

Table 18 SWOT analysis of the Basmanagua microenterprise waste collection project.

Strengths • The project focused on training & education of entrepreneurship (accounting, etc.). • The credit scheme follows the same concept of business approach • The members are well connected and maintain good networks to waste buyers and to municipal staff at the transfer station.	**Opportunities** • Leadership of the microenterprise was not considered an important factor as less important than being formalized and recognized.
Weaknesses • The period of raising awareness at household level was very short (2 months). Thus most households do not see the need to pay for services to the microenterprises, especially when considering that services by municipal truck drivers is free. • The owner of the microenterprises reported that cost of maintenance of the Italian vehicles has rapidly increased and the service stations are far out of town and thus difficult to access. Therefore they would prefer to change their vehicle to a Indian brand.	**Threats** • The municipality has not formally committed to a system which relies on primary waste collection and transfer stations, by microenterprises or cooperatives. Although currently accepted this may be subject to changes with changes in government. • The municipal waste collection truck arbitrarily change their routing when they foresee good yield of recyclables. (overlapping with the collection zones of the microenterprises) As this service is free, this conflicts heavily with the microenterprise interest also creating a reluctance of residents to pay for services.

A special effort was made by the project to formalize the microenterprises as part of the overall Managua solid waste master plan, through an endorsement by the municipality. An agreement was drafted but unfortunately never signed. Under the

currently acting political and administrative leadership in the municipality, the microenterprises and the transfer station are seen favourably and are accepted.

Financial support (50%) was obtained by the project from the Italian government to construct the transfer station which is managed by 4 municipal staff. Furthermore a credit scheme was set up to provide loans for the microenterprises. As the project has come to an end, the microenterprises now work independently. Collection of fees is done by staff of the microenterprises using a separate routing twice monthly, usually in the afternoons when more people are available at home. Some customers pay bi-monthly and other on a monthly basis.

Equipment & Technology: A credit scheme was made so that microenterprises could purchase their equipment which are motorcycle-trucks. The microenterprises are regularly paying back the credit. The equipment purchased was the not so widespread Italian brand "Piaggio" instead of the more common Indian brand. It seems a strange coincidence that the choice of vehicle and its origin is the same as the provenance of funds.

Project UN-Habitat

A UN-HABITAT project "Building Capacity in Solid Waste Management in Managua, Nicaragua" was developed to assist a larger projects funded by the Spanish government to rehabilitate the landfill of La Chureca. Four project components were developed in close collaboration with the municipal authorities (ALMA) as well as other stakeholder working in the sector. Among these one element was to improve the efficiency of collection and transportation of solid waste in Managua. In partnership with the municipal services a small transfer station was designed and is being built (Figure 30 - left) in District 6. The concept of a transfer station is linked to a primary waste collection systems with either tricycles, small motorcycle trucks (Figure 29 – right) or small tipper trucks depending on the distance of the collection route and a secondary collection by containers and larger trucks.

Organisational setup: The setup will be quite different from the other cases previously described, as in this project it will be the municipality which shall operate the primary collection schemes as well as the transfer station and secondary collection. Thus the service will be free of charge for residents. This setup may create some conflict with neighbouring areas service by cooperatives or microenterprises where residents must still pay for services.

Equipment & Technology: In discussion with project members doubts were raised on the appropriateness of the tricycles for waste collection, which had been recommended by the foreign consultant. On the other hand the Indian brand motorcycle-truck was considered to be very appropriate as it is widespread throughout the city with many mechanic shops know how to repair it and spare parts are easily available.

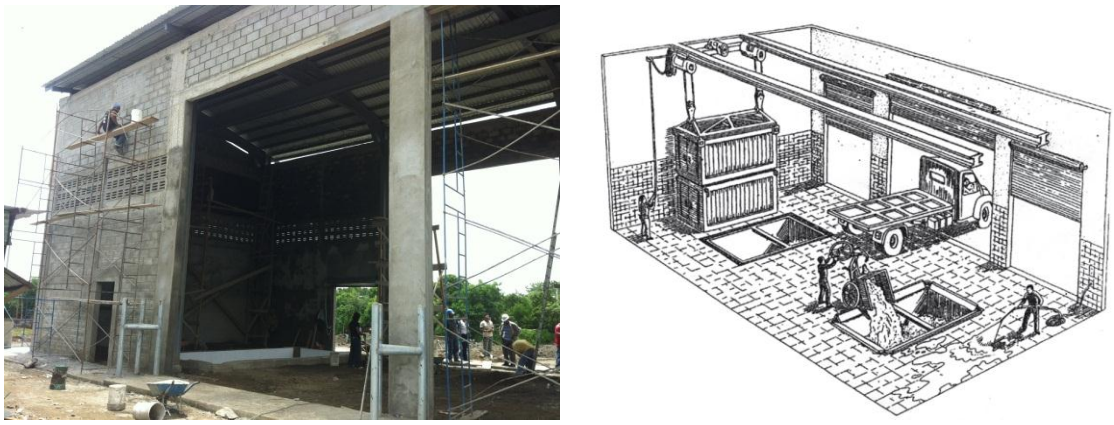


Figure 30 Construction site of the TS-Habitat transfer station in District 6 of Managua (left) and drawing of the same transfer station design (right), source (Coffey and Coad, 2010).

8.3 Stakeholder Analysis

Based on the results of assessment and in interaction with the interviewed stakeholders a stakeholder analysis and map were developed for the Managua primary waste collection case. The stakeholder matrix of interest and power (influence) is shown in Figure 31, whereby it shows the importance of stakeholders by darker shading.

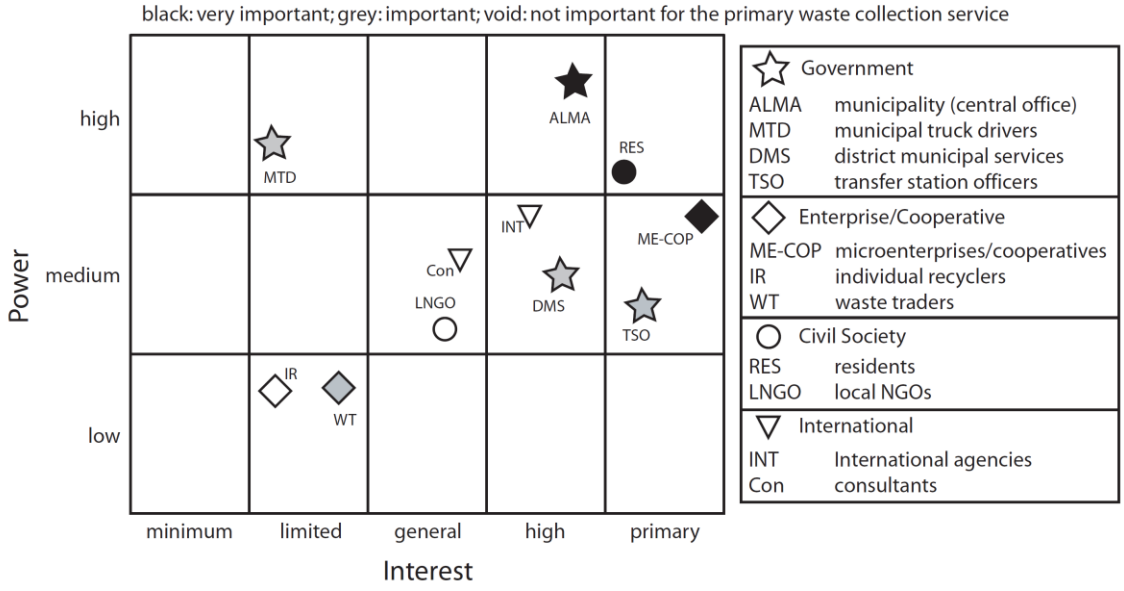


Figure 31 Stakeholder interest and power matrix for primary waste collection in Managua.

The matrix clearly shows the critical role of the municipal waste truck teams. Central municipal authority has little influence of ensuring their regular routes. They arbitrarily change their route depending on recycling opportunities and thus frequently overlap with an already existing primary waste collection service. As they provide service free

of charge, residents are always glad to use their service. In such cases the microenterprises remain without customers and hence without income. The municipality (ALMA) is also a key stakeholder with a high interest in ensuring a service for all. Nonetheless they have not integrated the primary waste collection schemes into the overall formal waste management strategy. The reason for hesitating is most probably the sensitive political issue of formally acknowledging that residents must pay for waste collection.

8.4 Conclusions

The cooperatives and microenterprises engaged in primary waste collection in Managua are considered an important element of the waste management system however are struggling to endure.

- *Supported by government and legislation (institutional and legislative aspects).* Although recognized and accepted by the municipality, there is yet no formal recognition and endorsement of primary waste collection by enterprises and cooperatives as an integral part of the solid waste management system of Managua. This may be a political sensitive issue as currently municipal services are free of charge while private and cooperative services charge a waste collection fee. Nevertheless in 2011 the Mayor of Managua, Daysi Torres Bosques is quoted during an opening ceremony of a new waste collection cooperative with the words (translated from Spanish) *"For us it is a great experience to be taken to other districts, the results have been effective for everyone, especially for those working in the waste collection"* (Rivas, 2011).
- *Enabled through an effective organizational structure (organizational aspects).* Both the microenterprise and cooperative form of organization are considered most appropriate for this type of service. Nicaragua has a history and culture of cooperatives and people appreciate this setup although it takes more effort and time to organize and formalize. Cooperatives need to be larger in size (minimum 12 people). Here some advantages in the economies of scale or easier access to capital might be expected.
- *Embedded in a financially sound setup (financial and economic aspects).* This is critical for cooperatives as well as microenterprises. Revenues only from waste collection fees do not suffice to ensure a viable business. Providing collection service but then only obtaining revenues through sale of recyclables also does not allow a profitable business. The primary waste collection schemes need both revenues streams, waste collection fees and sale of recyclables to ensure cost recovery and some profit. This delicate financial situation is very vulnerable to shocks. Vehicle breakdown (or longer downtime), loss of customers (or more non-payers), or some health problems of staff can easily upset the profitability of the scheme.
- *Uses technically appropriate infrastructure and equipment (technical aspects).* Given the financial vulnerability, the choice of appropriate equipment – which essentially is the vehicle – is critical. Using vehicles for which service and spare parts are not readily available or costly severely endanger the sustainability of the system.
- *Environmentally sound project (health and environmental aspects).* The waste collection activities reduce the amounts of indiscriminate dumping in the neighborhood which is appreciated by the population. Nevertheless there is no

means for the waste collection schemes to enforce service and payment and littering continues by those that not want to pay the collection fee. The collection activity as such does not result in any environmental emissions other than the combustion of fossil fuel by the vehicle.

- *Socially inclusive, accepted and supported (social aspects).* The staff of the waste collection schemes are from the neighborhoods and work for the neighborhoods. Residents know the waste collectors and continuously monitor their performance. Furthermore cooperatives enhance social cohesion in the neighborhood.

The use of the adapted assessment tool (see Chapter 6) proved useful for preparing and structuring the interviews as well as structuring the analysis and report. The questions easily guide the interviewer through the interview process while still ensuring enough flexibility to solicit new and unexpected information. It however proved difficult to obtain financial information which the interviewees either did not have or were not willing to share openly. Stakeholder analysis and mapping as well as a SWOT (strengths-weaknesses-opportunities-threats) analysis was also utilized during this case study assessment. Mapping however did not comprise a detailed network analysis but just tried to visualize the stakeholder and their ties rapidly during the interview. This information proved helpful during the analysis of interest and influence.

9 Case study: Primary Waste Collection in India

An revised version of this case study analysis was submitted and accepted for publication in: Proceedings of the ICE - Waste and Resource Management, Special Issue: Sustainable waste management in developing countries. The final submitted manuscript was reformatted and is attached in Annex 6:

Christian Zurbrügg, Silke Rothenberger (2012). Determinants of resilience in community-led waste management. Waste and Resource Management, themed issue for 2012: Sustainable waste management in developing countries.; Article number: WRM-D-12-00006

9.1 Introduction

Urban dwellers in developing countries are exposed to various environmental hazards in their daily life which are particularly enhanced by the urban dimension. Typically improved security and improved environmental sanitation services - particularly solid waste management - are often considered high priority in urban settlements. Self-initiative in solid waste management by individuals and local community groups is widespread as a coping strategy to overcome the lack of public services. This study aims at identifying and analyzing the driving forces for community-based initiatives in solid waste management using case studies from South-Indian cities. Furthermore it analyses internal and external factors which influence failure or success of such coping mechanisms. The analysis is based on results of a survey conducted at eight Indian community-based SWM schemes (Zurbrügg et al., 2004). Assumption is that such community-based initiatives are fuelled by a motivation and capacity to tackle the risks of deficient solid waste management infrastructure and services and that the individuals or groups avail of the capability to initiate and sustain - in interaction with other persons and organizations - coping mechanisms to deal with this risk. Individuals or group of persons may use different means to cope and achieve improvement. Knowledge, interaction and communication, access to social networks as well as financial capital are typical examples. To help describe the access to resources and means to cope, this paper uses the sustainable livelihood framework approach and its structure of "assets" and "transforming structures and processes" (DFID, 1999).

As a response to malfunctioning municipal services, self-help initiatives by individuals and local community groups is widespread in cities of the developing world (Anschütz, 1996). In the 90ies community-based management was regarded as the key solution to improve urban environmental sanitation and much international support was given to strengthen such initiatives. Still today this approach shows signs of success, where the poor are no longer the targets of externally designed and directed initiatives but the agents of poverty reduction (Satterthwaite et al., 2011).

Indian municipalities, similar to many others in developing countries, are also finding it difficult to keep up with the pace of the rapid urban growth and are most

often incapable of ensuring services let alone planning and dealing with the multitude of challenges of slums and informal settlements (Satterthwaite, 2005). As in many other developing countries however some 75% of the Indian urban citizens live in the bottom income segments, earning an average of 80 rupees (around 1.80 USD) a day (Sankhe et al., 2010), and most often live in informal settlements where precarious living conditions prevail. Also in India, self-organized local solid waste management (SWM) initiatives are a good example of coping mechanisms which grow out of such malfunctioning municipal services (Zurbrügg et al., 2004). Many initiatives are supported with knowledge and funds by local, national or international NGOs or other international agencies (Pfammatter and Schertenleib, 1996). However experience shows that external financial and technical support alone does not guarantee success (Ali, 2006). Many schemes failed soon after support phased out and even self-organized, bottom-up schemes in solid waste management which are not dependent of external funding tend to stop operation after a few years. The lack of support from and coordination/interaction with the responsible authorities severely endangers the sustainability of many initiatives. Especially in solid waste activities, coordination and collaboration with the authorities is required for secondary collection and disposal (McGranahan et al., 2001; Zurbrügg et al., 2004). This study is applies three different conceptual approaches to describe how motivation, social capacity and access to assets influences community initiatives and how these elements affect sustainability and success.

9.2 Methods and Materials

All data derives from interviews conducted during the research project "Decentralized Composting in Indian Cities" (Zurbrügg et al., 2004). The goal of that project was to determine the success factors and obstacles of decentralized solid waste collection and composting schemes in order to define new strategies for supporting such schemes in future. The focus of the previous study was set predominately on the composting activities. India was chosen for this study as it has a very active composting scene comprising commercial enterprises, public organizations and community initiatives. Twenty composting schemes of different size, organizational set-up and scope were interviewed. The semi-structured interviews addressed organizational, technical, financial and social issues in order to draw a full picture of each scheme. As the survey covered not only questions to assess the current status of the composting scheme, but also the start-up process and future prospects as perceived by the interviewed persons, it was thus possible to retroactively analyze the collected data with a new focus on resilience, on the five assets of the SLF, and the four factors of Protection Motivation Theory (PMT). Out of 20 solid waste management schemes surveyed, this analysis concentrates on eight community-based schemes, three each in the cities of Bangalore and Mumbai and one each in Chennai and Pune.

Protection Motivation Theory

Understanding the willingness and ability of individual or groups of people to act or not, in order to protect themselves from deficient urban environmental services such as a lack of solid waste and its hazards is complex. Protection Motivation Theory (PMT) (Rogers, 1975) reflects a theory of persuasive communication, emphasizing the cognitive processes that mediate behavioral change. In has been to environmental issues by researchers to analyze waste conservation measures (Untolaand and Syme, 1983) or for guiding communication campaigns that support water resource management (Nelson et al., 2011). PMT suggest that the objective to protect one-self is affected by four factors: (1) the perceived severity of a threatened event; (2) the perceived probability of the occurrence; (3) the perceived response efficacy; (4) the confidence in one's ability to undertake the recommended behavior (see Chapter 4.4.5). Semi-structured interviews conducted with the initiators of the community-based initiatives were analyzed in in light of these four factors, while taking into account norms (perception of what is the social expectation of behavior by others and by oneself) and habits (the ability to remember to act in a certain way) as defined in the RANAS model (Mosler, 2012) (see Chapter 4.4.5). Figure 32 shows the framework of analysis adapted after (Milne et al., 2000).

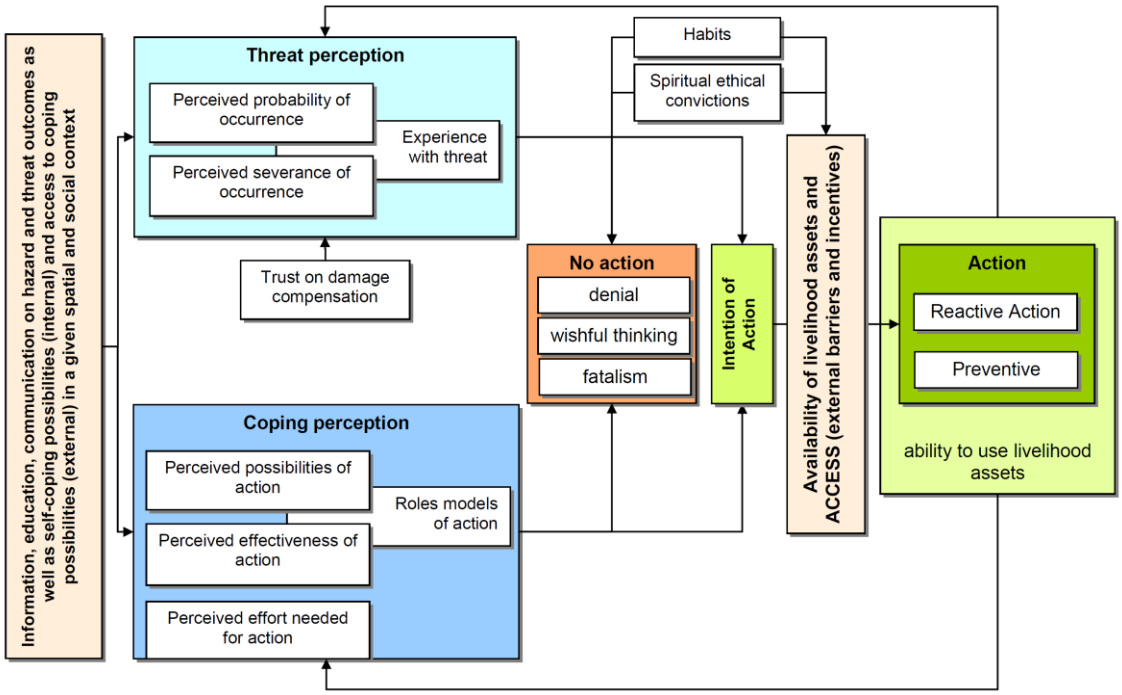


Figure 32 Framework of analysis based on Protection Motivation Theory (PMT), adapted after (Milne et al., 2000).

The Resilience Concept

Deficient urban environmental services and resulting sanitation or solid waste hazards gives rise to a more or less chronic crisis and therefore a constant threat to the inhabitants. Persistent hazard and chronic threat to health and wellbeing can

however also show intensification over time as the environmental system deteriorates further. The World Disaster Report 2004 claims that everyday threats are of greater concern than massive disasters (International Federation of Red Cross and Red Crescent Societies and Walter, 2004). The analysis of such hazards and threatening conditions and its effects on people is commonly used to describe the vulnerability of individuals or groups. Moser (1998) defines the term vulnerability in an urban context as *"insecurity in the well-being of individuals, households and communities in the face of a changing environment and their responsiveness and resilience to risks that they face during such negative changes"* (Moser, 1998). In contrast to vulnerability, resilience can be described as the means people have to cope with or even influence their environment. The ability of an individual or group to reflect on their current condition, to evaluate risks and to have confidence in their own competence and their ability to interact with other persons and organizations to deal with the risks of everyday life, forms the core of "resilience" (Obrist et al., 2010). In the urban context, community resilience can be described by the availability of self-help actions initiated either by individuals of community groups and - more importantly - sustained by the community as a whole with the objective to react to a precarious situation and try to organize themselves and act in order to improve their local situation. Such resilience shows the following attributes: proactive behavior, social learning, flexibility in actions and social acceptance. These characteristics can be regarded as personal or group assets which are available and can be used. This understanding of assets links to the sustainable livelihood framework approach.

The Sustainable Livelihood Approach

The sustainable livelihoods framework (SLF) is a way to enhance the understanding of livelihoods, main factors that affect livelihoods and the typical relationships between these factors. At the center of the framework, closest to the people, are the livelihood assets or capital which they have access to and can use. These are natural assets, human assets such as skills, education knowledge, capacity, and health, economic assets, physical assets such as technologies or infrastructure and finally social assets such as networks of social support (Chapter 4.4.4, Figure 13). The extent of access to these assets is strongly influenced by a vulnerability context and by the prevailing social, institutional and political environment also called the "transforming structures and processes", which affects the ways in which people can combine and use their assets to achieve their goals (DFID, 1999, 2001).

9.3 Overview of Community Initiatives

The eight decentralized composting schemes can be distinguished by their aim, their scope of activity and the economic classification of the neighborhood.

Table 19 gives an overview of the eight schemes included in the analysis.

Table 19 Analyzed community-based solid waste management schemes

Case	Aim of initiative	Scope of activities	Economic classification
Bangalore-1	Improving cleanliness by solid waste collection in the neighborhood.	180 households. House-to-house waste collection and composting as a means of waste reduction.	High income area, spacious properties and open public spaces.
Bangalore-2	Improving cleanliness by solid waste collection in the neighborhood and beautification of public spaces.	3826 households divided in three organizational units. House-to-house waste collection and composting for waste reduction.	middle income area with mixed housing pattern.
Bangalore-3	Improving cleanliness by solid waste collection in the neighborhood.	1200 households. House-to-house waste collection and composting for waste reduction; regular lectures on environmental issues.	Middle-high income area, partly with spacious gardens.
Chennai-1	Improving cleanliness in neighborhood, raising environmental awareness and community mobilization.	476 households. House-to-house collection of segregated solid waste, street sweeping and composting.	Lower-middle income area, dense housing and apartment buildings.
Pune-1	improvement of cleanliness of neighborhood and waste reduction to avoid overflowing municipal bins.	264 households. House-to-house waste collection, street sweeping.	High income housing communities with spacious garden and public places.
Mumbai-1”	Community mobilization and increasing social cohesion. Neighborhood beautification, increase of environmental awareness and well-being of inhabitants.	125 households. Waste segregation at source, house-to-house waste collection, street sweeping, public safety through street lighting, monthly rallies, annual environmental clean-up campaigns.	Middle income area.
Mumbai-2	Community mobilization and increasing social cohesion. Neighborhood beautification, increase of environmental awareness and well-being of inhabitants.	120 households. Improved solid waste collection for street beautifications and composting. Compost is used for new flower pots in the streets. Painting of walls.	High-middle income area, houses with small gardens.
Mumbai-3	improvement of hygienic condition within the slum	350 households solid waste segregation, composting, households voluntarily deliver waste to the composting site and the municipal public bin	informal settlement lacking infrastructure, community densely populated with simple houses or huts, located in an old stone quarry

9.4 Drivers to Improve the Immediate Environment

House-to-house waste collection service is generally not available in Indian cities. The household members are requested to bring their waste to the nearest collection point, which can consist of an open area with or without some constructed enclosing barrier, or else a designated container. In principle the municipal collection authorities should ensure that these collection points are regularly emptied and the waste is transported to the disposal site. However, the malfunction of public or even private services leads to unbearable environmental and hygienic conditions in the housing areas. Waste bins overflow regularly as municipal authorities cannot provide regular secondary waste collection service. The more unhygienic the collection points are, the less people tend to use them correctly or use them at all. This enhances indiscriminate dumping and unhygienic situation in the whole neighborhood.

As community members do not trust in the situation to improve in the near future, the detrimental hygienic situation puts much pressure on the residents to become active if they want to see any improvement. With regard to protection motivation theory (PMT) and the four factors that mediate behavioral change, results of interviews show that all respondents highlight the hygienic and environmental crisis in their neighborhoods and the perceived health threat of this situation (1: the perceived severity of a threat). Quotes: *"It was born out of a crisis. The local contractor was not emptying the bins in the neighborhood properly. The community then decided to take over the waste management themselves" (Bangalore-1); "Out of a desperate need to keep the colony clean we organized waste collection and initiated composting" (Pune-1).* In one case (Mumbai-3), it was mentioned that it was one individual that made the others in the neighborhood aware of the threat which then led to action - *"Waste was thrown out in front of the houses before people were made aware of the hygienic problem by a (female) bank officer living nearby"*. However no information could be obtained on the perceived probability of hazard occurrence and no specific incidences of health impact were mentioned which might have led to the action. Additional reasons for sparking the initiatives were also identified. Especially the examples of Mumbai grew from environmental awareness and the wish of the residents for a strengthened public responsibility and street beautification within the neighborhood. Solid waste management was only one among several issues tackled by the initiatives. In the context of PMT this links to the perceived response efficacy and the confidence in one's ability to make a change: *"Solid waste management is part of our street beautification program in order to maintain the streets clean. We thrive for more environmental awareness and social responsibility among neighbors and especially our children" (Mumbai-2).*

Another similarity of the schemes is the number of households connected to one scheme. With the exception of the inception phase, where they started small and then grew to include residents of the neighborhood, the initiatives then remained more constant in number of households served , as shown in Table 1. With the exception of two initiatives in Bangalore, all others serve less than 500 households. Size of an initiative is influenced by the perceived or effective feasible outreach into the neighborhood, or by the expected decreasing response efficacy if too many residents are involved. The more residents are involved, the larger the complexity of interaction

becomes and more difficult it is to achieve social cohesion and consensus within the group. The scheme Bangalore-2 which extends its outreach to over 3800 households is an exception as it is led and supported by a local NGO – with better trained and more available human resources and supporting funds. Bangalore-3 on the other hand developed a decentralized structure with sharing of key responsibilities among sub-groups in the neighborhood from the outset of the self-help initiative.

Except for one initiative (Mumbai-3) all initiatives are located in middle- to high-income areas. This might be due to a bias in selection of identified schemes as the local experts only had knowledge about the existence of these initiatives. However, it nevertheless becomes clear that more affluent areas show certain typical asset patterns which suggest that the existence of community-based initiatives is closely linked to available assets.

9.5 Livelihood Assets as Determinants of Resilience

The eight initiatives were further analyzed based on the five asset categories of the sustainable livelihood framework.

Human Assets – knowledge & skills

Knowledge or a high level education is an asset of almost all persons initiating such activities. The knowledge can be distinguished into the two levels: (a) societal awareness and (b) technical knowledge. The majority of the initiators of composting schemes hold a university degree which is most interestingly a degree in natural science or technology. It can therefore be deduced that the knowledge of natural and technical processes encourages initiators to start a rather technical oriented service such as composting or community-based waste collection. Many initiators are interested in the biological processes of composting and carefully observe and conduct detailed monitoring or optimize their composting heaps as a hobby. They furthermore also show skills in construction or in planning to optimize waste collection vehicles or composting bins. Even the case of the low-income area of Mumbai-3 shows that a teacher was the main driving force to maintain the composting site and the entry point was by starting planting trials with vegetables on compost. Motivation and dedication to the improvement action is thus often fuelled by the knowledge a person has, or the interest in enhancing and gaining more knowledge on this specific aspect. It is thus the resilience of an individual taking action inside the community which is decisive. Community (group) resilience is less relevant in the stage of inception.

The knowledge and experience from other urban areas and their respective living conditions is also a driving force, which can lead to action. Two interviewed initiators of initiatives (Bangalore-1 & 3) mentioned that they have been working abroad in America and Europe and that they had appreciated the cleanliness there. After their return they were motivated to maintain their neighborhood as clean as they had experienced abroad. They have a clear vision about what a neighborhood could or should look like. After realizing that the municipal authorities could not deliver this envisaged service they decided to become active themselves.

Conflict resolution, communication and management skills of the core members of the initiative are crucial to maintain motivation and participation of households. Inspired by a leadership course, the initiator of Bangalore-3 motivated the neighbors with the following principle: *"we are rather celebrating achievements than blaming shortcomings"*. Furthermore, he stated that each person brought in his/her own skills for the management of the community SWM system.

Human Assets – dedication & time

The analysis further revealed that dedication and time are two important assets for the start-up of community-based solid waste management and composting schemes. All work and commitment of the initiators and supporters of the reviewed initiatives to improve the situation is done on a voluntary basis or by a small payment which is significantly lower than in other fields of work. This clearly shows the dedication of these individuals to the cause rather than interest in the salary. But also time seems to be another important asset. Many residents involved are ladies without formal employment but dedicated to social work and their household and neighborhood surroundings. Analysis also shows that many retired persons started the initiatives to improve the cleanliness in their neighborhood.

Social Assets - network within the community, trust and reputation

The social network within a community shows to be crucial for the motivation of residents to cooperate as a community to improve SWM through a collection and composting system. All initiatives have in common that the initiator is a well-respected person in the community. This respect stems from the professional rank, political involvement or social activism and links to reputation and trust. In several cases the interviewees mentioned the importance of trust. The following examples show, that particularly women are trusted when it comes to financial issues: *"leading ladies, who enjoy the confidence of the community collect the waste fees"* or *"one trustworthy lady is collecting the fees monthly"*.

The initiators also see themselves in a leadership role inside the community which can be drawn from the following quotes: *"Leadership is not power but the opportunity to serve"* or *"The first chairwoman was active in local politics and had a sense for social issues. Social control was working as long as a strong leader was present. Now that she has withdrawn, households fall back to old habits"*. These leaders are able to establish alliances with friends and neighbors and define a common vision for the local solid waste management and composting project. Frequently project meetings and encounters are held at the private residence of this leader and initiator.

Special cases are the initiatives in Mumbai. As they were all developed with help of a semi-formalized structure provided by the municipal authorities. These initiatives are targeted towards community management as a whole where SWM is only one among several technical and social topics. This semi-formalized setup has been able to established strong social cohesion in some neighborhoods, which then shows significant benefits for the public space. When little support is available from

"structures" (institutions) then the resilience aspects of the individual (particularly of the leadership) plays are critical role as it is this person which pulls the strings and overcomes barriers. If this person then leaves, for whatever reason, survival of the initiatives can be severely endangered unless the leader has been able to find an appropriate replacement with similar assets. When, as in the case of Mumbai, the municipal authorities support the local initiatives in different ways, then it is rather the community resilience, social capital and sense of cohesion that plays an important role. In such cases "individual" resilience is less critical.

Social Assets - link to external agents and organizations

All respondents mentioned their need of support by other stakeholders or institutions that facilitate the community action through an enabling and supporting environment (in the sustainable livelihood framework this is summarized under "transforming structures and processes"). This is also confirmed by an analysis of Colon and Fawcett (2006) in Chennai highlighting the need for local resources, political, technical support and strong local leaders (Colon and Fawcett, 2006). Several schemes complained about insufficient support or even a jeopardizing role of municipal officers. Such statements - particularly from low-income groups - show how motivation is inherently linked to coordination and exchange of the community with official entities. People feel supported and feel their work acknowledged if the local government authorities show signs of recognition. In the cases of Mumbai - where municipal authorities offered a general clean-up of the area with heavy equipment (e.g. front loader and trucks to clean up illegal dumps) in exchange for the communities commitment to care for neighborhood beautification and payment to street sweepers or local waste collectors - the municipal officer is perceived by the community as very dedicated to the job: *"people listen to him as representative of the municipality".* Such support can also entail connecting the community to other external actors. Mumbai-1 for instance stated that they were inspired by the achievements of other community initiatives which were highlighted to them by the municipality. The initiative of Mumbai-2 established a link to a waste-picker association for the recruitment of reliable labor for their initiative. Others also take advice from time to time for technical matters from research institutes or private companies in the form of a consultancy service.

In summary the analysis shows that links to municipal authorities, NGOs, research institutes or even private businesses are very supportive in different ways. Firstly, they allow the recruitment of (suitable or qualified) workers for the scheme (waste-picker associations), secondly they can enhance knowledge transfer and networking, thirdly these connections and contacts provide potential opportunities for accessing funding sources for initial investments and finally, fourthly, they can strengthen visibility and acknowledgement by authorities. Particularly this last aspect is considered a key factor for the long-term success of a community solid waste management scheme as a link to the formal responsible authority is essential.

Natural Assets – access to waste

Major natural asset for solid waste management and composting schemes is the access to waste, which of course is given in all cases. Access to waste might however

change over time. When municipal strategies start to involve private sector for service delivery, they will compete with existing community-based collection initiatives. Given that this "new" service might even be free of charge, the community initiatives are bound to stop functioning although service level may not necessarily improve. This perceived threat was reported in the case of Chennai.

In community composting, the quality of waste plays an important role as composting initiatives require segregated biodegradable waste to achieve high quality compost. Hence, the initiative needs to motivate and engage households to segregate their waste at household level in two fractions: wet biodegradable waste and dry recyclable waste. In the interviews, motivation and cooperation of households is stated as something which is difficult to achieve and requires the initiator and social mobilizer to have excellent communication skills and be highly respected by the residents. Thus the aspect of social group peer pressure seems critical here where residents do what they perceive is expected from them by their social network. This example shows how closely natural assets and human and social assets are linked. Access to waste might however change over time.

Further examples for natural capital are the access to water and access to additives for composting (e.g. cow dung). Water is a crucial input material for composting and difficult access was mentioned as an obstacle in almost all cases. Only two schemes have access to a groundwater source or a tap. The availability of cow dung strongly depends on the financial assets, as in an urban setting cow dung needs to be purchased.

Financial assets – investment capital and recurring costs

Raising and managing financial capital is a major challenge in all assessed initiatives. Firstly, the schemes require money for the initial investment for infrastructure (collection carts, compost boxes, tools), secondly, recurring costs need to be covered continuously by regular revenues.

In high income areas the initial investments were less critical, as often the initiators invested their own money or used their social network to raise money for infrastructure and equipment. In Mumbai-2 for example, after a general clean-up the initiator was able to win a local music store to fund new flower pots as well as the compost bins. None of the initiatives analyzed had any access to loans. In the case of Bangalore-2, the NGO provided grants for the purchase of land and construction of infrastructure. In a few cases it was specifically mentioned that with the successful initial investment the collaboration of the residents then picked up. Once a first general clean-up was done and the infrastructure was in place, even hesitant households agreed to participate.

For the financial viability of a scheme, most respondents mentioned that acceptance and participation of all households is crucial. In all cases income from sales of compost or recyclables was low and does not cover the recurrent expenditures. Rather it is the regular waste collection fees paid voluntarily by the participating households which enables financial viability. Problems with fee collection and delays in payment however

seems to be the norm. The following two statements illustrate these obstacles: *"The richest are least willing to pay the waste management fee" (Bangalore-1)* or *"50 % are willing to pay, 40 % are reluctant and 10 % do not pay" (Bangalore-2)*.

The larger an initiative is, the more professional it must act and the more dependent it becomes on the financial contributions of the households. All analyzed initiatives depend on voluntarily paid fees and enforcement of payment is not feasible as these initiatives are informal organizational structures without a legal backing. The willingness of residents to pay is closely linked to the status of the person that is collecting the money. It shows that waste collectors, usually unskilled, uneducated labor and not well integrated into the social network, face difficulties if they need to ask for payments. They are not taken seriously, not trusted, and often also do not have the necessary self-confidence to put pressure on the residents to pay. On the other hand, "ladies" of the neighborhood are usually welcomed into the house by residents and residents then find it embarrassing to haggle or refuse to pay such a small monthly fee. Finances must be managed transparently to maintain the trust and satisfaction of the participating households.

Physical assets – infrastructure and access to land

Particularly infrastructure and land are key physical assets for composting schemes. Although in the urban area there is usually not much open and unused land available, the analysis of these existing initiatives however shows that even smallest strips of land are made available and used for composting. In Mumbai and Bangalore for example compost bins were constructed on top of drains or under high voltage power poles. In two cases, space was made available for composting by clearing an illegal neighborhood dump site. In these cases, the composting site was even more appreciated by the neighboring households, as the nuisances of the dump was removed. The initiatives of Chennai and Pune own the land they use and Bangalore-2 obtained an official approval by the municipality to use open plots for composting. The other initiatives are set up on unused public land without a clear and formal permission by the municipal authorities. Such an informal status constitutes a high risk to sustainability as the initiatives have to continuously fear sudden eviction by municipal authorities. These risk are somewhat averted by a strong social assets, i.e. good connections and relations to key people in municipal authorities or local politicians. It thus becomes evident how social assets are connected to availability and access to physical assets.

9.6 Conclusions

Assessments of strengths and weaknesses in solid waste projects often focus only on a physical, technical and financial description without taking into account the "human" factor (Ali, 2006). This analysis of these community-based initiatives in solid waste management performed in this study uses asset categories as defined in the Sustainable Livelihood Framework (SLF) and provides useful insights on the necessary preconditions and strengthening factors for community resilience in the urban sanitation context. It can be concluded that human and social assets are key to the

success of all community initiatives. All interviewed initiators revealed that the task of starting such a community activity is not easy and that they expose themselves to the public and become a subject of discussion in the community. It is only thanks to special human and social assets that such a task is feasible. Strong leadership, communication and networking skills and high social recognition are key attributes of all initiators.

As long as all members of the community participate and cooperate, such systems can sustain themselves. Nevertheless, given that neighborhood primary collection systems always depends on a secondary collection - which entails regular emptying of a municipal collection point and transport to the disposal site – there is a need to coordinate and collaborate with the next higher level: the municipality. This interaction is also crucial when considering the informal status of such initiatives, always at risk of being contested or dismissed. It is again the strong social assets of core members such as good connections and relations to influential people or key people in municipal authorities which can avert these risks. These findings are confirmed by Colon and Fawcett (2006) highlighting the need for significant local resources and political and technical support when initiating and operating community-based schemes. Sustainability of such schemes is difficult to achieve without strong local leaders (Colon and Fawcett, 2006). This pre-condition of strong leadership influences the potential of replication of similar schemes. In Mumbai, through the support and commitment of the municipality, replication of such initiatives is more obvious.

Understanding the drivers of community-based actions and the assets required to maintain them, finally allows a better planning and development of more targeted support to such initiatives - either through direct support such as training or by indirect support in facilitating a better enabling environment at municipal or national level.

That community-based schemes in solid waste management exist indicates a certain level of resilience of communities. They obviously have the ability to reflect on their situation, to judge risks and have the capability interaction with other persons and organizations to master the risks of everyday life. Each individual resident has only a limited impact on cleanliness other than in the private sphere. The neighborhood and public space can only be improved through collective and coordinated action by all stakeholders.

The assessment approach, using PMT to analyze the drivers and SLF and resilience to structure the results proved useful and beneficial and can be encouraged in future studies to evaluate the determinants of successful projects.

10 Case study: Waste Composting in Dhaka

Composting in Dhaka, Bangladesh was included in the selection as a case study as it represents a key story of success in organic waste management in low- and middle-income countries. The analysis focuses on the Bulta composting facility in the outskirts of Dhaka city, the capital of Bangladesh, but also includes the historical development of composting in Dhaka, and specifically the development of the NGO Waste Concern as the initiators of this activity and case.

10.1 Introduction

Bangladesh is one of the world's poorest and most populous nations. With a Gross National Income (GNI) of 780 USD in 2011 (World Bank Atlas Method, (The World Bank, 2012) it is one of the least developed countries in the world. With a population of about 150 million people it ranks 7th in the list of highest population density (1034 pop/km^2) countries. In consequence, waste management is a major concern.

Given the high biodegradable content of municipal waste (>70 %) the option of composting was identified as a potential solution about two decades ago. As composting is however not yet widespread at larger scale there is generally hesitation to choose this option as a viable waste treatment process for the organic fraction in developing countries. In fact many examples of failed projects form the negative opinion of waste composting. In an overview of experiences in Asia, Hoornweg et al. (1999) lists the following constraints on composting:

- inadequate attention to feedstock quality and the composting process, resulting in insufficient compost quality (inadequate pathogen and weed seed suppression) or environmental emissions (particularly odor)
- a focus on mechanized, capital intensive projects rather than labor-based processes, resulting in high costs of operations and maintenance
- a lack of strategy and marketing for the final product (poor integration with the agricultural community), resulting in low revenues
- competing products at low prices (subsidized fertilizer)
- poor management and accounting practices
- difficulties in securing other sources of finance since the revenues from compost sales will not be able to cover production costs
- land requirements.

Smaller scale decentralized approaches seem to be more successful (Zurbrugg, 1999) but often also struggle with the same issues as listed above (Rouse et al., 2008; Zurbrügg and Aristanti, 2000; Zurbrügg et al., 2004). There is much literature concerning the efficacy of compost use in agriculture (Rodrigues and Lopez-Real, 1998) highlighting the positive effects in terms of yield, moisture retention, organic matter replenishment and improvement in soil physical characteristics. Rodrigues (1998) advocates for waste compost to be used in urban agriculture for high value horticultural crops.

10.2 Methods and materials

The assessment systematically used the developed assessment checklist, as described in Chapter 6. Methods of data collection and inquiry was by:

- Literature and secondary data collection comprised a systematic search for information on the composting experiences in Dhaka and elsewhere in the region as well as the overall solid waste situation in Dhaka. Historical analysis: furthermore allowed to grasp the development over time with specific events that led to a change in situation or context.
- Two semi-structured, 3 hour interviews with the main initiators of the project. These key stakeholder have unique knowledge and experience not only with the case itself but also with the overall solid waste situation in Dhaka and the trends and development in the national policies and legislations of Bangladesh regarding solid waste management.

Results were then structured according to the proposed assessment format for reporting. A first draft of an excel-based software assessment tool was developed and also tested on this case study.

10.3 Description

Historical development in Dhaka

The city of Dhaka generates more than 4000 tons of municipal waste daily and the two Dhaka City Corporations (DCC) –North and South[1], in charge of solid waste management, collect only about 50% (Chowdhury and Afza, 2006; Enayetullah and Hashmi, 2006; Enayetullah et al., 2005). The other half remains on roadsides, open areas and is dumped in drainage channels or water bodies. Although the main landfill site of Matuail has been rehabilitated since 2007, with increasing population and increasing waste generation and limited waste collection capacity, providing adequate collection service and safe treatment or disposal remains a major challenge for the city.

The potentials of organic waste management as a possible contribution to the challenge of waste management in Dhaka, was recognized in 1995 by the NGO Waste Concern and its founders Maqsood Sinha and Iftekhar Enayetullah. Average composition of Dhaka's municipal waste shows a fraction of 78% of easily biodegradable food and vegetable waste (Enayetullah and Hashmi, 2006). First the activities of Waste Concern focussed on the areas suffering the most, the low-income slum areas of the city. Roughly 500,000 people move to Dhaka each year and most of these migrants then live in slums (Friedman, 2009). More than 3.5 million people (30 % of the total city population) live in slums with no waste collection services.

In selected slum Waste Concern initiated community-based waste management projects which included composting as the option for organic waste treatment. Composting barrels were distributed to families, one barrel shared among three to

[1] The previous Dhaka City Corporation (DCC) was dissolved and split into two, the North (DNCC) and the South (DSCC) City Corporation in December 2011.

seven families. Compost was bought by Waste Concern at seven taka per kilogram (100 taka = 1.23 USD) and the families shared the profits. Waste Concern then expanded their scope and started a first pilot project in Mirpur, a middle-income neighborhood of Dhaka. Early on in the process worked in partnership with government, private sector, local communities as well as international agencies and established a fruitful network of exchange and interaction while developing trust between all stakeholders (UNESCAP, undated). In the Mirpur neighborhood the project provided a primary collection system with bicycle carts. The household waste was sorted at the composting site and the organics composted on a vacant plot in the Mirpur Housing Estate which was made available by the Lions' Club (Zurbrügg et al., 2005). The organizational set-up of the collection and composting scheme followed a business approach, sustained by revenues from residents' payments for waste collection and from compost sales. The compost was sold to a large fertilizer company which further processed the compost and sold it to farmers throughout the country using their distribution channels and agricultural extension officers. Although agriculture contributes only 18.3 % of the Gross Domestic Product (GDP) of Bangladesh it employs 45% of the population (CIA, 2012); rice being the major agricultural product of the country. Waste Concern signed a written agreement with the fertilizer company wherein Waste Concern ensured the quality of compost as required by the customer and the fertilizer company committed to buying all the raw compost produced. Quality of the compost was checked and confirmed regularly by independent analysis of laboratory of Soil Resources Development Institute of the Government of Bangladesh as well as Waste Concern's own laboratory (UNESCAP, undated).

After gaining experience with the community-based composting facility, Waste Concern then started developing a greater scale composting project targeting the large amounts of organic waste generated in vegetable markets throughout the city. This then resulted in the launching of the large scale Bulta composting facility in collaboration with WWR Bangladesh Holdings Ltd. to form the joint venture of WWR Bio Ltd.

System Description

A) Describe the functions and elements of the case. B) Describe the goals and objectives of the case with regard to the service rendered or product developed.

The Bulta composting plant processes organic waste from vegetable markets which is delivered by contractors to the site. The element of waste transport is not assessed in this evaluation. The site is located on the outskirts of Dhaka as shown in Figure 33. The composting plant was designed for an input capacity of 100 tons/day and started operation on November 25th, 2008. Incoming trucks are visually inspected before they are weighed on the weighing bridge and then unloaded. After unloading the waste is again checked for inorganic material which if identified is removed manually and temporarily stored. The organic waste is then mixed with structure material (residual from the first sieving step) upon requirement and piled (with a shovel loader) into composting cells. These are 3 walled compartments which at the base have vents for forced aeration. Waste remains in these cells and is force-aerated by blowers for 4-6 weeks. Oxygen, temperature and moisture are measured regularly. Thereafter the pre-composted waste is moved to the maturing area where it is stack in open windrows for

another 4-5 weeks and turned regularly to ensure aeration and drying. Sieving then proceeds in two steps, a coarse sieving < 60 mm and then a finer sieving < 10 mm. The coarse residues above 60 mm are kept as structure material for incoming waste. Residues between 10-60 mm are returned to the maturation windrows. The fine compost end product is bagged and stored. On average, one ton of incoming waste 330 kg results in 330 kg of dry compost. The customer comes to the plant to collect the compost (UNFCCC, 2012b).

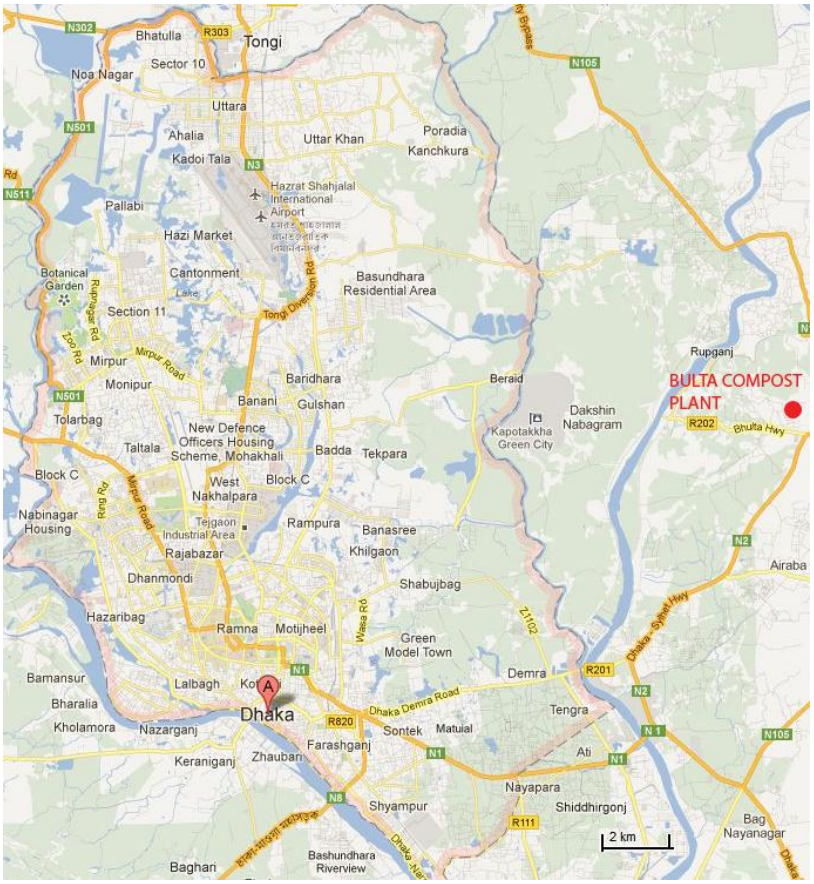


Figure 33 Location of the Bulta composting facility in relation to the city of Dhaka (city boundaries shown in orange), source Google maps and (UNFCCC, 2012b).

C) Describe existing competing activities of others. The Bulta plant is the only such facility in Dhaka and has long term agreements with one customer (ACI-marketing) for compost sales. Therefore they are not in major competition with others. It could not clarified if by initiating the Bulta project and ensuring waste from markets, previous other users of organic waste were then deprived of feedstock.

D) List technology elements used in the case. Describe if there any specific environmental, occupational health or safety threats associated with these technologies? This site includes a weighing bridge, shovel loader, blowers, roofed composting and maturation pad, leachate collection and leachate treatment, as well as storage sheds, office building and staff facilities. Staff is equipped with safety equipment (boots, gloves, masks). The normal labor related accidents may occur.

E) List and describe policies and legislation which exist in the country/province/city. In December 2010 the Bangladesh government issued the National 3R Strategy for

Waste Management (Department of Environment, 2010). Here is stated that: *"at present there are no guideline or rules available for management of solid waste in the country"*, and *"The country does not have a waste management strategy. As a result, waste management is viewed solely as an engineering responsibility for collection and disposal. Waste management is no more a technical issue. It needs social, fiscal and administrative solutions as well."* Table 3.1 of the National 3R Strategy for Waste Management, lists main policies, laws and regulations related to waste management and 3R in Bangladesh. This includes energy policies (re: biogas), agricultural policies (re: compost use) and urban policies (re: slum upgrading). The main policies of interest for the Bulta facility activities are those relating to compost use in agriculture. In 2006 the Fertilizer Act was endorsed which promotes compost and standards of compost have been set by the government in 2008 (Department of Environment, 2010).

F) List all the major stakeholders of the project and their ties.

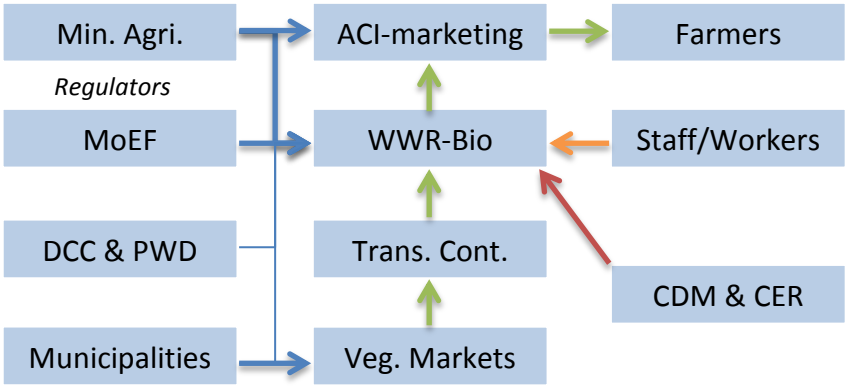


Figure 34 Main stakeholders of the Bulta composting plant

The rough sketch above shows the main stakeholders: Ministry of Agriculture (MinAgr) checks compost quality, Ministry of Environment and Forestry (MoEF) the compliance to environmental legislation. Both of these are regulators (dark blue arrows of relationship). Green arrows depict flow of goods (waste or compost), starting from the vegetable market (Veg.Market) to the transport contractor (Trans.Cont,), then to the Bulta facility (owned by WWR-Bio), then to the marketing company (ACI-marketing) and finally reaching the farmers. A further tie is between WWR-Bio and its staff. Finally the financial flow to WWR-Bio through the CDM project registration and the Certified Emission Reductions (CDM&CER). The graph shows the current somewhat detached role of the Dhaka City Corporation, Public Works Department (DCC&PWD), and the municipalities. This will probably change in the near future as the 3R strategy will designate DCC to be the only official "transport agent" for municipal waste, independent of its source and intended use.

G) Obtaining financial information with a breakdown on cost components. This data was obtained for the Bluta facility but cannot be published due to a confidentiality agreement. Suffice to say that estimates for 2013, based on 2012 expect the revenues to exceed the operating costs by a factor of 1.63 (depreciation of investment and recurring capital costs are not included). Furthermore the sales price of compost is increasing; in 2012 it has increased by 25% as tea gardens and international customers are becoming interested. The project is registered and approved by the Executive

Board of the Clean Development Mechanism under the Kyoto Protocol to the UNFCCC. Issuance of the first Certified Emission Reductions (CERs) will be available shortly and an International Development Bank has to the purchase of these CERs.

10.4 Assessing Critical Aspects

- *How have the aspects evolved over time (favorable or unfavorable)? How are the future perspectives in this regard? Is there anything the project team is doing to foster a future favorable development?*

Waste Concern, (i.e. now in joint venture as WWR-Bio) has started small and has several decades of experience with composting in Bangladesh. Over time they have built a solid network of contacts and are committed to producing an excellent quality compost. According to the planning in the CDM-project registration document two more plants shall be built in other parts of Dhaka to reach the total of 600 tons/day processing capacity

Institutional and legislative aspects

- *Are adequate policies and legislation in place and implemented to support the operation and existence of the case?*

YES. The recently launched National 3 R strategy falls in line and supports the composting activities. In addition the issuance of a quality label for compost of the Bulta plant by the Ministry of Agriculture, increased marketing potential and demand. Finally the company was also granted tax holiday until 2014.

- *Does the case comply with environmental standards and regulations concerning emissions to the aquatic environments, soil and groundwater?*

YES. One concern is the large amount of leachate generated at the composting site. Leachate however is collected and treated.

- *Does the case comply with quality standards of service and/or product as defined by legislation, standards and regulations?*

RATHER YES. Compost quality is regularly controlled internally as well as externally (Ministry of Agriculture) and comply to compost standards. No information was available on labor laws and worker health protection and respective compliance.

- *Is the case endorsed by, and does it obtain support by local and national authorities?*

YES. The City Corporation has signed a formal agreement to allow use of market waste at Bulta and the company was granted tax holiday until 2014.

Organizational aspects

- *Does the organization have a clear organizational status (formal or informal enterprise, NGO, CBO, cooperative)?*

YES. Formal registered joint venture company called WWR-Bio Ltd.

- *Does the organization have a clear and viable business model and plan, independent of its organizational form or affiliation and manage the project with responsibility, accountability and transparency?*

YES. Sound entrepreneurship is a fundamental principle of the company

- *Does the organization have dedicated talented leadership and dedicated skilled staff?*

YES. The leadership is extremely strong and technically competent. The founder of Waste Concern, now intrinsically involved in WWR-Bio have received the Klaus Schwab Award as Social Entrepreneurs and are esteemed worldwide for their excellent work, innovative spirit and commitment to the cause of solid waste management. They continuously pursue pathways of improvement for organic waste management and are influential in Bangladesh at all levels on aspects of waste management , carbon credits and resource recovery.

- *Are employee contracts attractive and conform or exceed to national and labor union recommendations (e.g. minimum salaries, work contracts, benefits, social security, insurance, etc)?*

RATHER YES. It was however reported that the project offers free meals for the workers, provides free health care and daycare facilities including a prayer hall/ mosque.

- *Does the organization interact successfully with other stakeholders in the system to structure and maintain a successful cooperation?*

YES. The relationship with transporting contractor and marketing company is excellent, whereas the relationship with DCC is difficult to assess.

- *Does the organization maintain a data monitoring system or benchmarking to evaluate performance?*

YES. Regular sampling of waste and compost, and monitoring of all performance indicators are requirements of the CDM project protocol.

Financial and economic aspects

- Is accounting and regular financial analysis an important part of the organizations operations? *This includes if breakdown of cost components is available and if there is regular monitoring and evaluation of cost effectiveness.*

  YES. Based on balance sheets provided, the cost components are available and listed with yearly expenditure and revenue summaries. Infrastructure depreciation was however not listed, nor were any recurring capital costs (interest rates).

- Is cost recovery of the project (revenues) viable and sustainable? *Do revenues outweigh the cost? Are depreciation reserves to renew equipment available and capital costs/ repayment of loans ensured?*

  YES. Based on balance sheets provided and estimates of future compost demand and prices cost recovery can be achieved. However depreciation cost of infrastructure and equipment as well as recurring cost of capital has not been included in the sheet provided

- *Does and can the project obtain access to capital (financial loans from different sources, e.g. banks, government, development agencies)?*

  NO INFORMATION.

Technical aspects

- *Is the technology appropriate and appropriately designed to operate under the local physical (e.g. climate, topography) and/or infrastructure conditions (e.g. roads, power supply)?*

  YES. Composting is proven in tropical zones. The construction of a roof allows better moisture control during monsoon rainy season. Forced aeration is used instead of turning by shovel loader. This implies electrical power replacing diesel fuel. The power grid and supply are however increasing under pressure and cannot fulfill the demand resulting in frequent power cuts. Therefore diesel generators were purchased as backup.

- *Is there sufficient local availability of know-how and experience (skills) to design and build the technology? Ideally construction would be possible with local available material resources.*

  YES. All infrastructure was designed and built with local expertise.

- *Is there sufficient local availability of know-how and experience (skills) to operate the technology? This includes it the employees/operators working with the technology been sufficiently trained?*

YES. Staff is available and continuously trained “on the job”. Bulta plant also frequently hosts plant managers from other countries (e.g. Nepal) to teach and train them on the job.

- *Can the technology be maintained and repaired easily by the staff? If not, is there an existing supply and service chain established that can do this timely and at an affordable cost?*

YES. Equipment is available throughout the country and can fixed rapidly and easily.

- *Can the technology easily cope with and adapt to changing conditions (e.g amounts or characteristics of waste)? If the technology be easily replicated and/or modularly up-scaled, this a sign of flexibility and adaptability.*

YES. Although only organic waste is accepted and there no provision for sorting other than manually remove some non-organics before movement to the composting cells. There is scope for scaling up at the site. An extension to 150 tons/day is being considered for 2013. Furthermore two more CDM composting plants are planned to open in 2013-2014 to handle a total of 600 tons of organic waste per day.

- *Has the most cost effective technology been selected for the project?*

YES. Composting with forced aeration is appropriate and functional for Bangladesh and has been proven in various occasions. Nevertheless the company is exploring new pathways for organic waste management such as anaerobic digestion and refuse derived fuel, considering that fuel and power are a scare and an expensive commodity.

Health and environmental aspects

- *Does the case prevent nuisances like bad smell, dust, noise and insects/animals?*

YES. The facilities follows monitoring procedures to assess all these emissions. These are documented in the yearly environmental report submitted to the government for license renewal and to the European shareholders.

- *Does the case safeguard workers’ well-being and health?*

YES. Safety equipment health care facilities are provided on site.

- *Does the case safeguard community well-being and health?*

YES. Procedures and mitigation measures to avoid health and environmental risk are documented in the code of conduct and the operational guidelines.

- *Does the case contribute to recovery and recycling of waste materials?*

YES. Organics are converted to compost. The few non-organics sorted after arrival, if of value, are also recycled.

- *Does the use make an effort to minimize use scarce natural resources or polluting energy sources? Ideally the case recovers energy from waste to reduce its own consumption.*

RATHER NO. Energy is consumed (electricity and diesel) but no energy is recovered. On the source and use of water no information is available.

Social aspects

- *Do beneficiaries (residents or local authorities) regard the case as socially beneficial and are they supportive to the project?*

RATHER NO. The project was not initiated by demand of the community. No information was obtained on how the residents perceive the composting plant given the larger amount of truck traffic.

- *Does the project empower local structures (development committees, user groups, consumer associations and elected representatives, etc.) and provide direct or indirect local employment opportunities?*

YES. The project creates job opportunities for the urban poor, especially for women and waste pickers. Indirectly, by increased use of compost in agriculture it increases yield and thereby income of farmers. Nevertheless there is no strong community involvement or any obvious direct empowerment expect for the livelihood opportunities provided for the workers.

- *Does the project provide equitable service or products, which also addresses the needs and potentials of the most vulnerable and marginalized groups of society?*

YES. The project creates job opportunities for the urban poor, especially for women and waste pickers.

- *Is community participation/involvement considered and implemented in the project?*

RATHER NO. Not much information is available in this aspects. The location of the plant is quite distant from any other settlements in midst of paddy fields, so this aspect might not be so relevant.

10.5 Conclusions

Bulta composting plant is indeed an excellent example of successful urban waste composting which is organized professionally and with an strong entrepreneurial spirit. All indicators point towards a high level of sustainability.

The assessment tool proved to be useful and robust. Some reworking of the questions could reduce repetitions. An attempt was made to structure the assessment tool in a excel-based software worksheet for use during the interviews. This did not prove to be very helpful as it distracts the interviewer from ensuring a nice flow in the semi-structured dialogue. This tool can however be used to document and visualize the results using spider diagrams. This is helpful when conducting repeated assessments on the same case over a time period as it will help visualizing changes (see chapter 4.6.2). Conducting a full assessment of all the aspects as listed above requires at least 3 hours of time. This is substantial and further research on the "most" critical factors (e.g. a prioritization or ranking) might be helpful to shorten the questionnaire.

Concerning ranking of critical aspects, in this case the interviewees were asked to share their opinion. The highest ranked aspect (based on two interviews only) was the aspect of quality control in compost product. To achieve this, a good and reliable supply of feedstock must be warranted and good knowledge and compliance with state of the art composting procedures must be enforced through competent and motivated staff. Second in ranking was a sound management of operations, which relates closely to the aspect mentioned above but also entails management skills, monitoring, accounting and reporting. Special reference was made for the need of flexible management and entrepreneurship given the frequent policy vacuum. Finally, the third in ranking was the importance of having an enabling external environment which pro-actively supports recycling activities while ensuring safe practices. The example of Bangladesh, with its 3R strategy, its licensing of recycling companies, tax exemptions and the endorsement of compost as a fertilizer by the Ministry of Agricultures, illustrates such a supportive environment.

11 Case study: Infectious Waste Management in Bangkok

An revised version of this case study analysis was submitted for publication in: Waste Management.

Marco Caniato, Mentore Vaccari, Chettiyappan Visvanathan, Christian Zurbrügg (submitted 2012). Using Social Network and Stakeholder Analysis to Help Evaluate Infectious Waste Management. Submitted to: Waste Management.

11.1 Introduction

This case study analysis had the objective to deepen the knowledge on non-technical aspects related to one specific field of waste management - health care waste management. All healthcare activities generate waste. Of this waste about 75-90% is similar to municipal waste. The remaining 10-25% is infectious/hazardous and requires special treatment as it may contain infectious materials, sharps, hazardous chemicals, pharmaceuticals, or radioactive substances. Given the hazardous nature of this fraction, contact and exposure to such waste is a health and environmental risk and can result in disease or injury (WHO, 2012). Therefore such waste needs special handling and treatment. Given that overall solid waste management still represents a major challenge of cities, especially in rapid urbanizing cities in the developing world (Diaz et al., 2005b), also safe management of healthcare waste poses a challenge to municipal authorities (Diaz et al., 2005a). Finding an optimal solution needs consideration of stakeholders (i.e. the human factor), next to the physical, technical, institutional and financial aspects as described in the concept of integrated and sustainable solid waste management (ISWM) (Van de Klundert and Anschütz, 2001).

The health care waste management system in Bangkok, in particular the On-Nuch infectious waste incineration plant is considered by solid waste experts as a good example in Asia (ISSOWAMA, 2010, 2011b). An detailed assessment therefore has the objective to verify this claim and evaluate some determinants of success and critical aspects which can then be to improve operations or for future planning. Special focus of this study is dedicated to the social aspects and interaction of stakeholders rather than on technical issues.

11.2 Methods and Materials

Social network analysis (SNA) and stakeholder analysis (SA) were used as main tools to evaluate the non-technical aspects and assess which of these are perceived to be of higher importance than others for sustainability and success of the waste management scheme. Analysis focused in particular on the central element of this system, the On-Nuch incinerator.

Data collection was during a period of one month in June 2011 and comprised the following:

- A systematic search for secondary data and subsequent document analysis. Data obtained from secondary sources such as documents and reports ,were crosschecked with newer documentation and through specific questions in the interviews.
- Field observations
- Key informant interviews for identification of main stakeholders as well as identifying the main elements of the waste management system and its historical development
- Semi-structured interviews with selected stakeholders to obtain information on elements of the waste management system in question, specific stakeholder interests and power relationships, and interactions (networks) with other stakeholders
- Key informant interviews of selected individuals with unique knowledge/personal experience of the investigated issues
- Stakeholder analysis
- Interviews or focus group discussions with individual stakeholders or stakeholder groups, which included a SWOT analysis used to understand the Strengths, Weaknesses, Opportunities, and Threats involved in the project.

As qualitative data were collected, it was particularly important to have a clear and defined description of each assessed topic. Hence, the following definitions were settled, in order to properly conduct interviews and to address data processing:

- Knowledge: Knowledge and awareness of components, operations, actors, challenges and potentialities. It varies according to interviewee interest and characteristics;
- Position/opinion: Stakeholder position regarding a specific issue or, as in this case, his opinion about a system;
- Interest: The interest a stakeholder has about the specific case to be analyzed which comprises , when, why and how the stakeholder has been involved or perceived to be involved;
- Alliances: Clear and stable agreements between actors to meet the same objective concerning the case;
- Power: Stakeholder capacity or perceived capacity to affect a policy or the case, in terms of access and availability to resources and the possibility to mobilize and effectively use them.
- Leadership: It was considered as additional aspect to the “Power” category. Leadership was defined as the capacity to and will to lobby for a certain issue concerning the case or successfully involve other stakeholders and their resources to affect the case. A stakeholder usually shows leadership when there are one or more strongly committed individuals in key positions with a certain power to convert potentials into practice. A special leadership role was defined as “champion” that describes a specific individual who has played or plays a key role in the case. The champion’s work and commitments are recognized by other stakeholders as being very significant for the success of the case development or ongoing operation and it is merit of the particular dedication as an individual and not only as representative of the own organization. A “champion” thus shows

the characteristic of being highly committed, well linked to other stakeholders especially to those showing strong power of decision and influence, having good expertise on the subject of the case and highly respected by other stakeholders. Typical properties of a champion could be summarized by the terms: charisma, commitment, dedication, subject expert, proactive problem-solver, strategic thinker, and networker.

Table 20 Parameters and value scales used in the stakeholder interview questionnaires.

Parameter	Value Scale
Information quality: This parameter concerns the self-reported general information of the case as available to the interviewed stakeholder from specific sources. This value was also further revised and normalized based on crosschecking with other data sources.	Scale of 1-10 whereby: 1. Very low quality (1 - 2) 2. Low quality (3 - 4) 3. Acceptable quality (5 - 6) 4. Good Quality (7 - 8) 5. Very good Quality (9 - 10)
Knowledge on others: This gives a value for the knowledge of the stakeholders interviewed with regard to roles, functions and duties of other stakeholders. Considering the provided description of other stakeholders, answers were crosschecked with available data (self-description, documents, official website), and finally categorized	Considering 3 classes: 1. Low knowledge 2. General knowledge 3. Complete knowledge
Interaction: This defines the level of interaction between the stakeholder interviewed and other stakeholders indicating frequency of interaction.	Considering 3 levels: 1. Rare interaction 2. Quite frequent interaction 3. Frequent interaction
Interest in the case: This describes the self-reported level of interest of the interviewed stakeholder in the case as specified by the interviewee. This value was also further revised and normalized based on crosschecking with other data sources, and consistency with other quantitative and qualitative answers.	Scale of 1- 10, whereby: 1. No or minimum interest (1 - 2) 2. Limited interest (3 - 4) 3. General interest (5 - 6) 4. High interest (7 - 8) 5. Primary interest (9 - 10)
Expert knowledge: This describes the self-reported level of knowledge of the interviewed stakeholder regarding the case. Self-defined knowledge was reviewed considering the provided description of the case and all the stakeholders knowledge, highlighting 4 classes	Scale of 1- 10, whereby: 1. No or minimum knowledge (1 - 2) 2. Lacking knowledge (3 - 4) 3. General knowledge (5 - 6) 4. Deep knowledge (7 - 8) 5. Complete knowledge (9 - 10) After review, and revision: 1. No or minimum knowledge (1 - 3) 2. General knowledge (4 - 7) 3. Complete knowledge (8 - 10) 4. Not available or not applicable
Power: This reports on the self-declared perception of power, based on availability and access to resources and the ability to mobilize them.	Scale of 1- 10, whereby: 1. Low power (1 - 3) 2. Medium power (4 - 7) 3. High power (8 - 10)

Data was processed using the "definitions of stakeholders characteristics". A tool, proposed by Schmeer (1999), was adapted to the case before starting interviews and acted as a guide during the interview to collect consistent information. This involves clarifying the terminology in use, and development of a final database, called "stakeholder table", where data are entered for analysis. In addition, the "transfer reference table" tool was used to further support the data entry process, linking questions with database fields. Normalization was also required to revise evaluation scores of all the collected information. Such procedures were carried out once interviews and data collection was terminated. Data were verified, normalized and converted from given scores (in brackets) as shown in Table 20. Social network analysis and graphical representation was conducted using UCINET software (Borgatti et al., 2002).

11.3 Stakeholder Analysis

On-Nuch infectious waste incineration plant is the only legal treatment facility currently available for healthcare infectious waste in Bangkok. It serves the whole metropolitan area, is owned by Bangkok Metropolitan Administration (BMA) and is managed by Krugthep Thanakom Ltd. (KT), a non-profit public utility company controlled at 99.8% by BMA itself. BMA, as the local government agency responsible for Bangkok waste management, is in charge and responsible for healthcare waste collection, treatment and disposal. Based on a Ministerial rule on disposal of infectious waste, pursuant to the Public Health Act of 2002 which allows public private partnerships in waste management, BMA chose to contract the service out to KT Company in the 1998. This company deals only with healthcare waste, in particular infectious waste as other waste typologies follow different flows, mainly managed by other private companies for BMA. Considering the large number of healthcare facilities operating in the area and the presence of many authorities both at national and local level, understanding the responsibilities of each in the waste system is complex. In fact several actors are directly or indirectly involved and make the situation more dynamic and unclear. Healthcare waste production in Bangkok is continuously increasing and the On-Nuch incinerator plays a key role to properly manage the infectious waste stream.

All stakeholders could be assigned to one of five stakeholder groups. These groups are defined as shown in Figure 35 as:

- governmental authorities (local as well as provincial or national);
- private sector (only formal enterprises, as the informal sector was not mentioned by interviewees nor observed to play a role in infectious waste management);
- academia (universities, education and training institutions and research centers);
- Non-governmental organizations (NGOs) and civil society organizations; and
- other stakeholders.

Considering the system in general, opinion of stakeholders is generally positive, as they recognized improvement: however stakeholders showed a general mistrust

particularly for both waste incineration and plant management. About incineration they were generally worried about potential impacts, mainly concerning dioxins. Even emission control mechanism, with regular certified flue gas analysis (by a private company, TET) does not look a sufficient guarantee. Then the management of the plant, both in terms of operations and equipment, is generally considered not completely adequate.

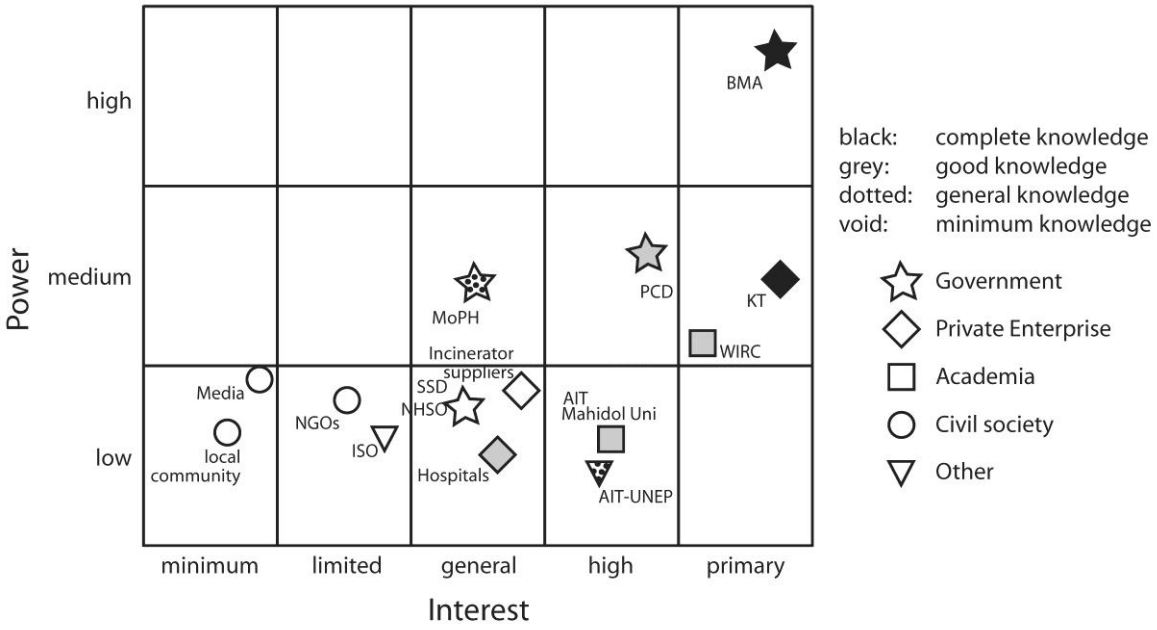


Figure 35 Stakeholders level of interest in infectious waste management of Bangkok and the power to influence and determine the course of infectious waste management, as defined in Table 1.

Governmental authorities

BMA: BMA is clearly a key actor, as the local governmental authority in charge for the service. BMA is owner of the infrastructure and assigns the contract for operation. BMA oversees the operation of the incineration facility, ensures financial resources and is key to all planning and decision making activities.

MoPH: The interest of MoPH, the Ministry of Public Health, concerning health care waste management is high. Nevertheless given their role to oversee and regulate practices in hospitals and clinics, their concern relates to the aspects of waste generation and to a lesser degree on what happens with the waste once it leaves the hospital and clinic premises.

PCD: The Pollution Control Department (PCD)as part of the Ministry of Environment, is concerned about pollution and measures to avoid it, and clearly focuses its interest on the incinerator as a means of treatment to avoid pollution. PCD in general is concerned about developing directives for treatment or if necessary planning for alternatives to incineration. PCD influence the operation of infectious waste incineration as regulator, to ensure environmental protection and has the power to intervene if the incinerator does not comply with environmental legislation.

MoL/SSD: Inside the Ministry of Labor (MoL)the department of Social Security (SSD)is considered relevant as this department manages the national workers health insurance fund. SSD is an indirect major customer of hospitals, as it pays considerable number health care bills of all national employees. In this function it also rates and ensures the quality of hospitals. One ranking criteria is how hospital waste is managed and SSD defines the expected levels of quality. SSD has less interest or influence on what happens once the waste leaves the hospital premises.
NHSO: A similar stakeholder is the National Health Security Office(NHSO) which ensures universal coverage of health care for all Thai citizens and manages the operations of the National Health Security Fund. One of its functions, similarly to SSD, is to control and supervise health care units and their networks to provide health care services which are up to the standard of service prescribed by its Board.

Private sector

KT: Krungthep Thanakom Ltd. (KT)operates the incineration facility and is concerned to enhance efficiency and reduce cost to thus increase profits. Thus their interest in the issue of infectious waste management is high and their power to affect the outcome is also high. Nevertheless they depend on BMA, as their direct customer of services and the owner of the infrastructure they are using. Technical system configurations and equipment replacements are not in control and power of KT but rather with BMA. As such KT can be considered as manager of an existing facility, doing its task but does not show signs of innovation, research and development from a technical or systemic perspective.
Hospitals: Hospitals and clinics show high interest concerning health care waste management. They recognize that haulage, treatment and disposal are important steps but, as this is not considered their duty, they are less involved in any decision-making or strategic planning in this regard. They are interested in the development of the sector as any change in the system may affect them and the fee they are paying. They are thus interested in finding the most “low-cost” solution for infectious waste. Interest and active involvement would increase if increase of fees were to be expected, which however is not the case.
Incinerator suppliers: These were cited a few times by various stakeholders as important stakeholders. The role of technology supplier is clearly recognized by various stakeholders, however at the current phase of infectious waste incineration in Bangkok the role of the equipment suppliers is limited as the technology has been chosen and is now in operation. The main supplier’s role is to supply spare parts or replacement of equipment. Their contact to other stakeholders besides KT and BMA is very limited. Their knowledge is focused on the incineration technology and not on the whole chain of management. Their role and interest would increase when BMA starts planning new facilities.

Academia and Research

The various academia and research stakeholders such as the Asian Institute of Technology (AIT), School of Environment, Resources and Development, or Mahidol University have a high human resource capacity and knowledge which they use in training, analysis, planning and consulting. Financial resources are however limited and

thus also the opportunity to conduct any (research) activity. They have high recognition of expertise by other stakeholders and although they themselves do not have direct decision-making power, their views and recommendations indirectly affect infectious waste management. As topic of their academic focus, they show interest in what is happening and make efforts to stay informed. Academics themselves see their research work to have impacts and influence especially for medium and long term decisions and see their role looking at the larger system and its dynamics, to consider the wider consequences of technical choice, and impact on health and environment.
The Waste Incineration Research Center (WIRC) at King Monkut's University has a special role as it is more frequently hired as consultant and trainer of waste management staff. Therefore it reports to have more power on specific decision-makers.

NGOs and civil society

NGO: NGOs represent or mobilize public opinion. They are recognized as key stakeholders, but no specific NGO involved or interested could be named. An NGO brought to the attention of PCD that there other treatment option than incineration The current low interest and engagement of NGOs, might change rapidly when discussion start about increasing the capacity to treat infectious waste.
Local community: few people live close to the incinerator many of which are employed in waste management activities. Some few work close by on other jobs. Only few of them are informed about what is being processed in the incinerator. They are affected less by the incineration facility then by the vehicles transport the waste (smell, dust, noise of trucks continuously passing).

Other stakeholders

The United Nations Environmental Protection Agency (UNEP) has a regional subsidiary office (Regional Research Centre for Asia and the Pacific) at the Asian Institute of Technology (AIT-UNEP). This stakeholder was mentioned in some interviews as an important hub for information on health care waste management. It does not have a regulatory role, and thus not have much formal power in decision-making. Rather it acts upon request by government authorities as consultant to advise on policy making level. Other stakeholder such as the local ISO office (International Organization for Standardization) were mentioned in interviews but cannot be considered of much importance to the infectious waste management system of Bangkok. ISO certification procedures affect hospital waste management in terms of the ISO Standard ICS 13.030.30 on special wastes.

Analyzing Power, Interest and Attitude of Stakeholders

Analyzing data concerning interest and attitude of stakeholders towards infectious waste incineration in Bangkok shows a generally positive picture (Figure 36). Key stakeholders with higher level of power in decision-making are very supportive. This concerns BMA as well as the regulatory governmental authorities. The analysis, however, also shows that a large number of secondary stakeholders are currently either neutral or indifferent to the current practice of infectious waste management.

These are not well connected to each other and no specific alliances could be identified. For BMA and KT this constitutes a certain risk as these stakeholders may rapidly change their opinion following a specific event. Maintaining good contacts to all these stakeholders with open and transparent communication could act as interesting preventive measure. Hospitals and clinics were difficult to assess as they are many and scattered around the whole city. In general the results show that they are satisfied with the system, more affordable than an in-house treatment solution. In interviews they also voiced a doubt about incineration as an appropriate solution although they do not know of a better solution at hand. NGOs are skeptical about waste incineration. However, as the system is currently working without flaw, it receives little attention nor complaint.

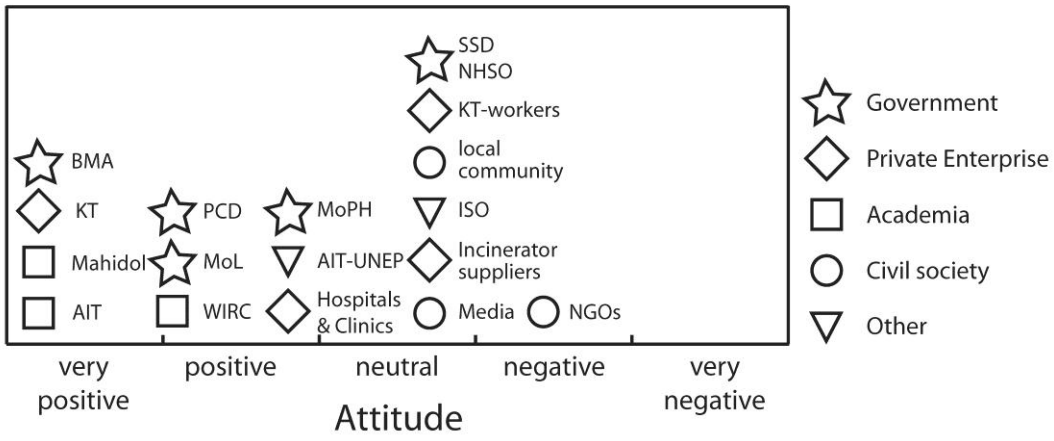


Figure 36 Stakeholders attitude towards infectious waste incineration in Bangkok.

11.4 Network Analysis

Regarding information flow among stakeholders, an overall assessment (Figure 37) shows that although some stakeholders are only partially connected to others, nobody feels really cut off from the information flow. In fact obtaining all necessary information is generally easy for most stakeholders. An exception is the local community which has no direct ties to any other stakeholder and limited access to information. When analyzing the stakeholder's level of knowledge many gaps were identified. Only few stakeholders are well aware about how the infectious waste management system of Bangkok operates and show little interest to inform themselves. This situation may however change once discussions start on new incineration facilities or alternative technologies.

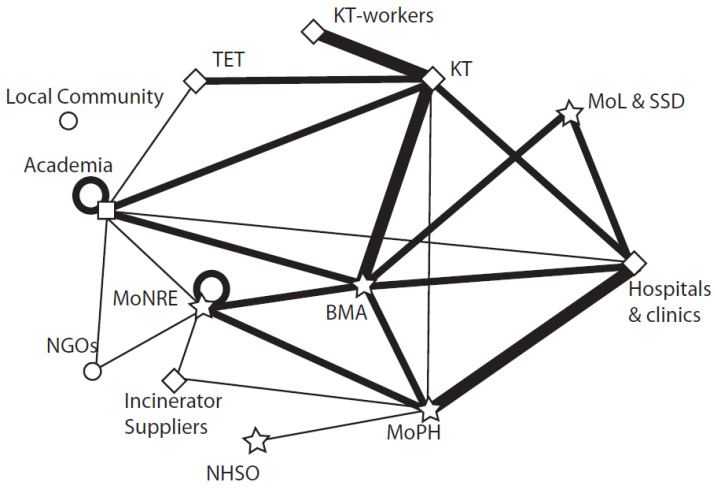


Figure 37 Social network diagram of information and interaction showing three levels of exchange frequency (line thickness shows frequency of exchange).

Knowledge is quite polarized between who plays a key role (and has power and a good opinion of the system) and who is either not or only slightly involved (with little power and little particular interest). BMA is central in the network of information exchange with good ties to all other major stakeholders of government, academia and private sector. MoPH is also central given its strong ties to the hospitals and clinics. It acts as knowledge hub to the stakeholders of the health sector. Academia and PCD (part of MoNRE) also play an important role regarding information exchange. Academia is well positioned and considered a useful ally by all stakeholders as it is perceived as independent and evidence based rather than representing political or business interests. Here it would be advisable to strengthen the ties to hospitals and clinics and the health sector in general so that Academia can play a better intermediary role of knowledge broker between the engineering/waste management sector and the health sector. PCD (MoNRE) has good knowledge of the system and obtains all information from the main stakeholders. They can potentially act as intermediaries and independent actors linking the operational units of waste management to civil society organizations.

11.5 Conclusions

Stakeholder analysis techniques are currently considered state of the art in non-technical assessment procedures and have proved their value also in this assessment. The addition of using social network analysis has additional benefits to better assess and understand the interaction among stakeholders. An interview-based mapping procedure helped people understand, visualize, discuss, and suggest improvements to situations in which many different actors influence outcomes (Schiffer and Peakes, 2009). The use of graphical tools facilitated interviewees to focus their attention not only on speech, but also on a visual representation of their views. Prompting stakeholders to give scores (evaluation and self-evaluation) was generally considered successful and was appreciated by the interviewees who liked the idea that perception and subjectivity was not in the interviewers hands but rather transferred to the interviewee. In some cases however, stakeholders voiced their uneasiness to score

other stakeholders, especially if considered as their close partners. Clear communication by the interviewer regarding confidentiality of information helped alleviate the situation. One limitation of SA and SNA is its mapping of one moment in time. Hereby the process and development of a project showing how successively project improvements, modifications of roles, perceptions and attitudes cannot be captured. This could be somewhat rectified by two different assessments: past and present. Nevertheless this increases complexity for the interview and time demands.

Concerning On-Nuch infectious waste incineration plant in Bangkok, the assessment shows that system is working to satisfaction and is appreciated by all stakeholders as a good solution. The institutional arrangement with the BMA maintaining ownership and responsibility of the task while contracting KT as a private enterprise to operates the facility can be considered appropriate. The clients, the hospitals and clinics, do not have to take care of waste treatment and are content to pay the respective fees. The system of infectious waste incineration underlies clear regulatory rules and is supervised by the Pollution Control Department (PCD) as part of the Ministry of Natural Resources and Environment (MoNRE). Network analysis shows that BMA is well connected to a wide range of other stakeholders such as academia, provincial and national authorities, civil society and, of course, also the main customers, e.g. the large hospitals. Other minor stakeholders know how they can obtain information but currently choose to not to, as they are not overly concerned with the current processes of infectious waste treatment. A potential sudden change of attitudes should not be underestimated if some negative event happens in Thailand or elsewhere and is spread through media. Frequent open and transparent communications of BMA with all stakeholders concerning infectious waste management is advisable to strengthen trust in the current technology solution.

PART 4

12 Conclusions

This chapter summarizes the key findings and research results of this thesis. It starts by reminding the reader of the research objectives, followed by the research conducted and results achieved. A second section then summarizes the results from the five case studies (part 3).

Local governments and their waste managers, consultants, researchers, NGOs, and development agencies are still struggling to find ways to improve the solid waste situation in urban areas of low and middle-income countries. Existing services and infrastructure are often dysfunctional or lacking. Consequently, a threat to public health and severe environmental pollution result and it is the poorest most vulnerable fraction of the population that suffer the most under these conditions. This situation is the main driver for this thesis, which is to find ways to help improve this deplorable situation.

Many years of trying technical engineering approaches have not shown much progress. Infrastructure and equipment rapidly falls into disrepair, residents are disappointed and municipal officers are frustrated, not knowing what to try next. Upgrading solid waste management sustainably is not only a technical and engineering challenge, but it requires the thoughtful integration and consideration of public awareness and participation, socio-cultural factors, organizational & managerial features, coordination of stakeholders, financial and economic issues, institutional, legal and political questions. The modern waste manager labels this holistic approach: "Integrated Sustainable (Solid) Waste Management" (ISWM). There is evidence of such ISWM projects which have succeeded in improving the waste situation. Documentation of success unfortunately, is often falls reduced to describing only the technical aspects without including all the dimensions of sustainability. Nevertheless, the process of mutual learning from what works and what doesn't - and why - is an important element, where policy makers, practitioners and experts can exchange experience and knowledge. This is considered key to improved, coordination and decision making (Godfrey et al., 2012a).

What did successful projects do that others could learn from? The overall objective of this thesis is thus to assess existing favorable framework conditions for sustainable solid waste projects in low- and middle-income countries and then provide support to a wide variety of stakeholders so that they can improve the planning, design, implementation and continuous adaption of waste projects and thus contribute to sustainable development.

In this regard, this thesis has developed a set of assessment tools which help one evaluate and document existing solid waste projects and identify their performance with regard to critical aspects of sustainability (*research question C1*). A questionnaire-based tool was developed through an interactive process, which consisted of:

a) studying existing assessment methods and tools (*research question A1*) as they are applied in different disciplinary sectors: water, sanitation and solid waste engineering, environmental and health science, economics and finances, social studies, psychology, business and management, and from the field of sustainability science;
b) testing a combination of existing and self-developed assessment tools in selected "best practices" case studies of Asia and Latin America (*research question D1*).

Using the tools in field studies allowed the author to gain knowledge and experience of their usefulness and receive feedback and suggestions from local stakeholders on how to best develop the tools further (*research question D2*).

The current version of the developed questionnaire-based assessment tool has two sections

1) In the first section the user is guided to describe the "case" to be assessed in terms of its goals and objectives and the functions and boundaries of the system that shall be evaluated.
2) The second section is structured according to critical aspects namely:
   - *Supported by government and legislation (institutional and legislative aspects)*
   - *Enabled through an effective organizational structure (organizational aspects)*
   - *Embedded in a financially sound setup (financial and economic aspects)*
   - *Uses technically appropriate infrastructure and equipment (technical aspects)*
   - *Environmentally sound (health and environmental aspects)*
   - *Socially inclusive, accepted and supported (social aspects)*

A template assessment form is provided in Annex 4.

Validation though case studies and dialogue with experts confirm the assumption that the "critical aspects" included here are those that, if fulfilled, contribute significantly to project sustainability and success (*research question B1*). Not all aspects however rank equally in their importance. It will be the specific waste project scope - be it primary waste collection, composting, recycling and recovery centers or landfill management – and the local enabling (or disabling) environment which will determine the importance of each aspect. It is therefore essential for any waste manager and decision-maker to keep abreast on this "enabling environment", monitor changes and evaluate who and what could be done to foster change in the environment in favor of the project or then adapt to it with project modifications. In order to make the right choices when developing strategies or planning investments, understanding the context is especially relevant early in the project cycle (between identification and appraisal). Most existing assessment methods target this phase by evaluating expected environmental and/or socio-cultural and socio-economic impacts in relation to the available alternatives.

Literature review has shown that in academic solid waste management work the use of the Life Cycle Approach (LCA) is most frequent and well accepted. Although the focus still heavily remains on environmental emissions and impacts, increasingly social and economic aspects are being included into complex system analysis platforms for decision support. The use of LCA or these more complex platforms is however, still unusual for solid waste decision problems in low and middle-income countries. If applied, it is for academic research purposes only and not for practice. The barriers lay in the large data requirements. To facilitate their use in practice, many of these tools rely on inventory databases, which however, seldom contain data specific to low- and middle-income countries. This thesis proposes an "enabling environment" assessment approach (*research question B2*) based on the sanitation planning approach suggested by Lüthi, et al. (2011) and the ISWM assessment methodology (Anschütz et al., 2004). Integrated into this overall assessment approach, are selected tools which are derived from existing methods of the different disciplinary sectors. Linked to the concept of feasibility assessment, the tool proposes to evaluate: (i) the enabling environment, (ii) the technology choices based on the principles of appropriateness, (iii) the social suitability assessed through stakeholder and social network analysis, (iv) the economic feasibility using methods of financial analysis, and (v) the assessment of expected environmental emissions. Stepwise guidance is proposed on how such assessments can be conducted and which tools are used at each stage of the process (*research questions E1 and E2*).

Results from case studies analyses show that some common key features of successful solid waste management projects are frequently overlooked when planning projects. These are:

- *Effective organizational structure:* This entails having an organizational setup which operates the project that is clearly defined in its goals and objectives, has a strong forward looking leadership and skilled, motivated and continuously trained staff. The organization operates under the principles of entrepreneurship, commitment to a high quality of service, customer care, accountability, transparency, and equity.
- *Viable business model and financially sound setup:* This involves ensuring a well-developed business model and business plan, the capacity to mobilize investment capital and a well-conceived sustainable mechanism to recover capital and operational costs through reliable revenue sources over a long-term project period.
- *Endorsement by government and compliance to legislation*: This requires that the project is recognized by the government as an integral part of the overall strategy and is in accordance with national laws, regulations, standards and codes.

Case study: composting in Gianyar, Bali

The Gianyar project, which is comprised of composting of the biodegradable waste, is a good example of a highly integrated approach that accounts for the different elements of project sustainability. Attention was paid already during the planning stage to both technical appropriateness and to involving the local authorities (regency

and village). This gradually led to a more comprehensive approach and finally to the organisational involvement of these institutional actors as well as a hand over of responsibilities to the respective entities. Technical appropriateness was not optimal from the start, and stills offers potential for improvement. However, the assessment also revealed that the motivating factors to achieving improvement are on-going and continuous. Finding the necessary investment capital was not an easy task due to the limited "best practice" experiences required to convince prospective funders. Future composting projects can benefit from this case as a "demonstration case" to prove that it can work, thus making it easier to solicit funds from donors.

One decisive factor of success is "leadership", embodied in a strong, dedicated "driving force" with an excellent network of contacts and the ability to advocate and motivate other people and organizations to get involved. This issue might be an obstacle when planning for replication as such individuals - such "driving forces" - are not easily available for appointment. A careful hiring process committed to detecting the abilities and leadership qualities of applicants is required. Furthermore, training and education needs to be designed, not only to build competent capacity in engineering and science, but also in leadership skills, teaching entrepreneurial spirit, commitment to a high quality of service, customer care, accountability, transparency, and equity.

In Gianyar, an unresolved challenge relates to attaining cost recovery through a good marketing strategy of the compost products. In Indonesia fertilizer is subsidized by government, making it difficult for compost to compete financially. Obtaining governmental support for compost sales – for example through quality labelling and endorsement of compost by the Ministry of Agriculture – would be very helpful for marketing. Registering the project with the Clean Development Mechanism was helpful however, as CERs are granted after verification and are therefore low at the start and increase over time (due to the "avoidance of methane production from biomass" method) this does not solve the problem of needing upfront capital to get started. In summary, the low cost, low tech and low risk approach of this project is likely to act as a model for replication in Indonesia and other developing nations.

Case study: primary waste collection in Managua

The cooperatives and microenterprises engaged in primary waste collection in Managua are considered an important element of the waste management system. However, they are struggling to endure. Although recognized and accepted by the municipality, there is not yet formal recognition and endorsement of primary waste collection by enterprises and cooperatives as an integral part of the solid waste management system of Managua. This may be a politically sensitive issue as currently municipal services are free of charge while private and cooperative services charge a waste collection fee. Nevertheless, in 2011, during an opening ceremony of a new waste collection cooperative, the Mayor of Managua said: *"For us it is a great experience to be taken to other districts, the results have been effective for everyone, especially for those working in the waste collection"* (Rivas, 2011). So there is hope that the situation will improve in the near future. Both the microenterprise and cooperative form of organization are considered appropriate. In the political environment of Nicaragua, cooperatives are common and also enhance social cohesion in the

neighborhood. Revenues only from waste collection fees do not suffice to ensure a viable business but must include sale of recyclables. The delicate financial situation is very vulnerable to shocks. Vehicle breakdown (or longer downtime), loss of customers (or more non-payers), or some health problems of staff can easily upset the profitability of the scheme. Given the financial vulnerability, the choice of appropriate equipment –the collection vehicle – is critical. Using vehicles for which service and spare parts are not readily available or costly, severely endanger sustainability.

Case study: primary waste collection in India

The analysis in India looked at the motivation and capacity of individuals and groups to initiate, operate and sustain community-based waste collection initiatives. Community-based schemes in solid waste management exist and this indicates a certain level of resilience of communities and their ability to reflect on their situation, to judge existing risks and to trust in their own capability to master the risks of everyday life in interaction with other persons and organizations. Each individual resident however, has only a limited impact on cleanliness other than in the private sphere. The neighborhood and public space can only be improved through collective and coordinated action by all stakeholders. The analysis concludes that human and social assets are key to the success of all community initiatives. Strong leadership, communication and networking skills and high social recognition in the community are key attributes of all initiators. As long as all members of the community participate and cooperate, such systems may sustain themselves. However, given that a primary collection systems always depends on a secondary collection, it is essential to coordinate and collaborate with the next higher level: the municipality. This interaction is also crucial when considering the informal status of such initiatives, i.e. they are always at risk of being contested or dismissed. It is again the strong social assets of core members such as good connections and relations to influential people or key people in municipal authorities who can avert these risks. This pre-condition of strong leadership influences the potential of replication of similar schemes throughout a city. In Mumbai, by support and commitment of the municipality, replication of such initiatives is more easily achieved.

Case study: waste composting in Dhaka

The Bulta composting plant in Dhaka was shown to be an excellent example of successful urban waste composting which is organized professionally and with a strong entrepreneurial spirit. All indicators point towards a high level of sustainability. One of the partners in the joint venture (Waste Concern) started small about two decades ago by gaining experience in composting in Bangladesh. With time, they have built strong technical competence, a solid network of contacts and the knowledge of how to get things done in Bangladesh. They are dedicated to quality control and excellent work, a principle they also demand from all staff and that is enhanced through regular training and education. They show innovative entrepreneurial spirit and are continuously pursuing pathways for improvement. Financial viability is ensured through revenues from compost sales based on a long-term sales agreement a with fertilizer company and by income through CERs as a registered CDM-project. Also, the enabling environment for waste management and composting is very favorable. In Bangladesh,

the recently launched National 3 R strategy falls in line with and strongly supports the composting activities. To incentivize recycling activities the government grants tax holidays for licensed recycling enterprises. In addition, the issuance of a quality label for compost by the Ministry of Agriculture has increased market potential and demand. When, during the research activities, the interviewees were asked to rank the critical aspects, the aspect of quality control of the compost product ranked first, sound management ranked second, and the enabling external environment ranked third. Maintaining good quality compost entails a good and reliable supply of feedstock and good knowledge of and compliance with state of the art composting procedures by competent and motivated staff. Sound management of operations relates closely to quality management and requires sound management skills and a strategy of monitoring, accounting and reporting.

Case study: infectious waste management in Bangkok

Concerning the On-Nuch infectious waste incineration plant in Bangkok, the assessment shows that the system is working to satisfaction and is appreciated by all stakeholders as a good and sustainable solution. Here, it is not the leadership of an individual that is decisive but rather a strong and competent organization that is well connected to other stakeholders. Bangkok Municipal Authority (BMA) maintains ownership of the infectious waste incinerator and responsibility of the tasks, while contracting Krungthep Thanakom Ltd as a private enterprise to operate the facility. The clients, the hospitals and clinics are content to pay the respective fees which are perceived as affordable. The system of infectious waste incineration underlies clear regulatory rules and is supervised by the Pollution Control Department (PCD) as part of the Ministry of Natural Resources and Environment (MoNRE). Social (stakeholder) Network analysis shows that BMA is well connected to a wide range of other stakeholders such as academia, provincial and national authorities, civil society and, of course, also the main customers, i.e. the large hospitals. Other minor stakeholders know how they can obtain information but currently choose to not to, as they are not overly concerned with the current processes of infectious waste treatment. A potential sudden change in attitude should not be underestimated if some negative event happens in Thailand or elsewhere and is spread through media. Frequent open and transparent communications of BMA with all stakeholders concerning infectious waste management is advisable to strengthen trust in the current technological solution.

13 Outlook

In this thesis, the explicitly identified reasons for using and further developing assessment methods for decision support were twofold:

a. Using well-defined assessment methods on existing cases we can analyze their performance/impact (in all sustainability dimensions) and understand how and why the performance/impact is as it is.
   I. Each case assessed and analyzed can help identify the specific weaknesses in that moment of time. With the identified weakness then mitigation measure can be evaluated and implemented to rectify the situation and improve performance of negative impact.
   II. Using a standardized methodology on different cases allows their comparison. With a large number of cases assessed, the information obtained can help establish some general valid factors of performance success or failure in projects. This knowledge can then help decision makers avoid the same mistakes other have already experienced or highlight how specific risks during project development and planning can be avoided early on.

b. Using assessments for prospective analysis of project scenarios can help in evaluating and comparing between options, be this different financing models, technology elements or and organizational setups.

For analyzing existing cases a questionnaire-based assessment tool has been developed. It is now the moment to apply this tool in as much cases as possible. A frequent use of this tool in practice can validate its usefulness or contribute to subsequent improvements. Is the tool applicable to other low- and middle-income countries or other solid waste management cases, which regard other sources and types of waste? What about dispersed rural areas or the management of special wastes from certain economic sectors (mining, agriculture, industry) or specific locations (ports, military camps, industrial zones, etc.)?

By using the tool and by exchange with local stakeholders, project managers and other waste management experts, the claims of what are the “critical aspects” can also be verified and if necessary amended.

The assessment tool developed for prospective analysis, with focus on enabling environment, technical appropriateness and financial feasibility, takes many existing assessment tools into consideration. It however focuses more on what data to get and what methods to use to obtain information. More work is now needed in developing a simple and robust tool to classify the alternatives based on a set of preferences.

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PART 5

Annexes Overview

Annex 1: The Business Model Canvas template

Annex 2: Stakeholder Analysis

Annex 3: Aspire indicators of sustainability

Annex 5: Determinants of sustainability in solid waste management – The Gianyar Waste Recovery Project in Indonesia.

Annex 6: Determinants of resilience in community-led waste management

Annex 1: The Business Model Canvas Template

After (Osterwalder and Pigneur, 2010)

The Business Model Canvas

<table>
<tr>
<td rowspan="2">Key Partners
Who are the key partners?
Who are the key suppliers?
Which key resource are acquiring from partners?
Which key activities do partner perform?</td>
<td>Key Activities
What key activities are required for:
- our value propositions?
- our distribution channels?
- customer relationships?
- revenue streams?</td>
<td rowspan="2">Value Propositions
Which value do we deliver to the customer?
Which one of our customer's problems are we helping to solve?
What bundles of products and services are we offering to each customer segment?
Which customer needs are we satisfying?</td>
<td>Customer Relationships
What type of relationship does each of our customer segments expect us to establish and maintain with them?
Which one have we established?
How are they integrated with the rest of our business model?
How costly are they?</td>
<td rowspan="2">Customer Segments
For whom are we creating value?
Who are our most important customer segments?</td>
</tr>
<tr>
<td>Key Resources
What key resources are required for:
- our value propositions?
- our distribution channels?
- customer relationships?
- revenue streams?</td>
<td>Channels
Through which channels do our customer segments want to be reached?
How are we reaching them now?
How are our channels integrated?
Which one works best?
Which ones are most cost efficient?
How are we integrating them with customer routines?</td>
</tr>
<tr>
<td colspan="3">Cost structure
What are the important cost inherent in our business model?
Which key resources are most expensive?
Which key activities are most expensive?</td>
<td colspan="2">Revenue Streams
For what value are our customer really willing to pay?
For what do they currently pay?
How are they currently paying?
How would they prefer to pay?
How much does each revenue stream contribute to overall revenues?</td>
</tr>
</table>

Source: www.businessmodelgeneration.com

Annex 2: Stakeholder Analysis

Adapted after (Mosler, 2004; ODA, 1995; Schmeer, 1999).

What is a stakeholder analysis?

Stakeholder analysis is the identification of a project's key stakeholders, an assessment of their attitudes, interests, and influence and the ways in which these affect project riskiness and viability.

Doing a stakeholder analysis can:

- draw out the interests of stakeholders in relation to the problems which the project is seeking to address (at the identification stage) or the purpose of the project (once it has started).
- identify conflicts of interests between stakeholders, which will influence project's riskiness
- help to identify relations between stakeholders which can be built upon, and may enable "coalitions" of project sponsorship, ownership and cooperation.
- help to assess the appropriate type of participation by different stakeholders, at successive stages of the project cycle.
- drawing up lists and diagrams in such a manner can help share and clarify information quickly.

However, stakeholder analysis often involves sensitive and undiplomatic information. Many interests maybe covert, and maybe agendas partially hidden.

Definitions

Stakeholders are persons, groups or institutions who are affected by the project and/or affect the project. This definition of stakeholders includes both winners and losers, and those involved or excluded from decision-making processes.

- Key stakeholders are such who can significantly influence or are important to the success of the project.
- Primary stakeholders. This includes the individuals and groups who are ultimately affected beneficiaries (positively or negatively impacted)
- Secondary stakeholders are all the other individuals or groups, institutions or organizations with a stake, interest or intermediary role in the activity but not in a position of significant influence.

3 steps in doing a stakeholder analysis

There are 3 steps in doing a stakeholder analysis:

1. identify stakeholders and develop a stakeholder table;
2. assess each stakeholder using interviews and questionnaires on aspects of attitude interest towards the project as well as the relative power and influence potential on affecting the project's success
3. identify risks and assumptions which will affect project design and success and devise appropriate mitigation strategies.

Identifying stakeholders

Divide the list into key, primary and secondary stakeholders. To reduce the risks of failing to identify important stakeholders, it is helpful to use a combination of approaches: Ask yourselves the following key questions:

- Who are the (potential) beneficiaries?
- Who is or will be adversely affected?
- Who has existing rights?
- Who is likely to be voiceless?
- Who is likely to mobilize resistance?
- Who is responsible for the intended plans?
- Who has the money, skills, or key information?
- Whose behavior has to change for success to be reached

Information on who is a stakeholder can be obtained:

- by staff of key agencies
- from written records
- stakeholder self-selection
- verification by other stakeholders, allow stakeholders to assist in the identification of other stakeholders
- random method: Ask every single person who they think is or would be affected by a certain issue or project.

  Checklist for identifying stakeholders
  * have all primary and secondary stakeholders been listed?
  * have all potential supporters and opponents of the project been identified?
  * has gender analysis been used to identify different types of female stakeholders (at both primary and secondary levels)?
  * have primary stakeholders been divided into user/occupational groups, or income groups?
  * have the interests of vulnerable groups (especially the poor) been identified?
  * are there any new primary or secondary stakeholders that are likely to emerge as a result of the project?

Drawing out stakeholders' attitudes, interests and influence in relation to the project

The list of stakeholders forms the basis of a tabulation of each stakeholder's attitude, interests in and influence on the project. Interests may be drawn out by asking:

- what are the stakeholder's expectations of the project?
- what benefits are there for the stakeholders?
- what resources does or will the stakeholder commit (or avoid committing) to the project?
- what other interests does the stakeholder have which may conflict with the project?
- how does the stakeholder regard others in the stakeholder list?

To acquire the desired information, however, it is necessary to establish open, lively, and fruitful dialogue between the parties. Key actions to endure good quality dialogue include:

- ensure that stakeholders trust the convener

- enable dialogue, not a one-way information feed
- ensure parties are sufficiently prepared and briefed to have well-informed opinions and decisions
- involve stakeholders in defining the terms of engagement
- allow stakeholders to voice their views without restrictions and fear of penalty
- include a public disclosure and feedback process
- create incentives for participation
- create feeling of belonging through shared vision / objectives

Stakeholder characterization

	Attitude	Interest	Influence	Importance	Options / ways forward
Stakeholder A					
Stakeholder B					
Stakeholder C					
Stakeholder D					
Stakeholder E					
Stakeholder F					

Influence is the power which stakeholders have over a project - to control what decisions are made, facilitate its implementation, or exert influence which affects the project negatively. Influence is perhaps best understood as the extent to which people, groups or organisations (ie. stakeholders) are able to persuade or coerce others into making decisions, and following certain courses of action.

Importance is distinct from influence. When assessing importance to project success, use questions such as:

* which problems, affecting which stakeholders, does the project seek to address or alleviate?
* for which stakeholders does the project place a priority on meeting their needs, interests and expectations?

Combining interest and influence in a matrix diagram

This is done by positioning stakeholders in relative terms according to the two broad criteria in a two by two matrix.

	Low interest	High interest
High influence	*Mitigate impacts, defend against*	*Collaborate with*
Low influence	*Monitor or ignore*	*Involve, build capacity, and secure interests*

By assessing the interest and influence of key stakeholders, some risks emerge from the matrix diagram. Measure for mitigating these risks can then be developed. This will imply a revised set of activities.

Annex 3: Aspire indicators of sustainability

INSTITUTIONS	
Skills	Local government involvement: defined responsibilities during different phases, available skills and resources to meet these responsibilities, project, project aligned with policy and programs? Private sector involvement: consideration and role, capacity and skills to build, operate and/or maintain? Civil society involvement: role of citizens and civil society, capacity and skills to construct, operate and maintain? Research and Innovation: innovation a core value and feature of the project, resource allocated to research and development?
Policies	Regulatory quality: Government's ability to formulate and enforce sound policies and regulations, risk of policies and regulation uncertainty on project? Human rights: project assessed with regard to impact of human rights, procedures in place to monitor? Health and safety: compliance with health and safety standards, identified and managed workers health and safety risk? Quality assurance: procedures in place? Intellectual property rights: knowledge and practice remain in property of community?
Reporting	Information disclosure: transparency of information and decision making? Monitoring and evaluation: procedures in place, involvement of stakeholders in monitoring and evaluation? Media channels: media channels used effectively to access all audiences? Replication: knowledge and lesson learned exploited to share with others?

ENVIRONMENT	
Air	Ambient air quality: local air pollution, impact of project monitored? Direct emissions: project designed to minimize exposure of humans flora and fauna to emissions, target set and measured? Dust and particles: measures in place to control, minimize and monitor? Ozone depleters: any ozone depleting substances used or emitted? Indirect emissions: any identified, monitored, fuel type used?
Land	Site location: previously undisturbed land, selected to minimize impacts, at risk to natural hazards? Planning intent: conform to land-use planning? Diversity/mixed use: basic service available, provision of basic services also to residents? Contaminated land: contaminated previously, remediated, possible impact? Soil conservation: ensure that soil is protected?
Water	Drainage systems: taken into account, increases runoff and infiltration into groundwater, minimize impact of water flows and quality? Water pollution: source of pollution identified, minimize discharge of pollutants, monitored, liaison with regulatory bodies? Sewage treatment and disposal: managed to minimize impact and monitored? Water availability: extraction of water quantified, impact monitored? Water efficiency: designed to minimize water consumption, monitored?
Biodiversity	Protected areas: designed to avoid or minimize effects on protected areas? Nature conservation: impact on biodiversity, measures taken to minimize losses on biodiversity? Aquatic ecosystems: impact on aquatic ecosystems, measure taken to minimize these effects? Forests: effect on forests, measures taken to minimize effects? Drylands: effect on drylands, measures taken to minimize effects? Environmental risk management: hazards and risk identified and procedures

	developed to manage developed?
Energy	Energy efficiency: designed to reduce energy usage, monitored and controlled? Energy sources: renewable energy source considered and included?
Materials	Material efficiency: designed to reduce total material use, maximize use of recyclables, procedures implemented to reduce waste? Responsible outsourcing: procurement of sustainable goods and services, suppliers controlled? Whole life analysis: infrastructure design to have flexibility to adapt for future usage?

ECONOMICS	
Viability	Value for money: cost-benefits assessed? Risk management: identified, monitored and mitigation strategies defined and implemented? Carbon pricing: future cost of carbon considered? Operation and maintenance: identified and costed, revenue streams identified to cover operating costs? Alignment with national/regional strategies: conform to national regional development strategies, plans and policies? Appropriate technologies: suitable for local context?
Macro	Vitality and regeneration: socio-economic baseline, sectorial profile, local supply chains assessment undertaken? Value added/multiplier effects: opportunities to improving local production? Debt: project financially viable? Inflation effects: budget prepared considering local wage levels? Ethical competition: competitors identified and consulted?
Livelihoods	Local sourcing: maximized local sourcing? Access to financing: affordable finance available? Distortions of local economy: potential negative impacts of project on local economy, strategies and measure to minimize these in place? Employment creation: project priority on labour intensity, local employment? Labour standards: employment sufficient to provide basic standard of living, no child labour, workers rights upheld? Training: project includes training activities, addresses skill gaps?
Equity	Equal opportunities: provision of equal opportunities, removed barriers for disadvantaged groups? Affordability of services: minimum service appropriate and affordable, ability of poorest considered? Accrual of benefits: anticipated benefits identified and equitably distributed, who is disadvantaged and how will this be dealt with? Land tenure: clearly defined, how are local communities affected?

SOCIETY	
Population	Vulnerable groups: identified who, design to minimize impact of these? Population change: how population may change due to project or how it will be affected by population change? Community cohesion: encourages dialogue and collaboration between groups? Conflict sensitivity: current and potential conflict in region, impact of project on conflict? Displacement: project impact on displacement?
Culture	Socio-cultural identity: project recognition and integration of local and cultural traditions, impact of project on these? Cultural and religious facilities: project accessible to all religious and cultural groups? Local heritage and archaeology: assessment of impact on heritage places and features? Use of environment: project integration of natural and man-made features in the local environment? Intergenerational and gender practices: assessment of differential impact on men and women and different age groups, consideration of local preferences in roles

	in gender, religion, age?
Stakeholder	Identification and analysis: assessed and consulted? Consultation and participation: integrated into project design? Accountability and grievance mechanisms: complaint and concern feedback possible?
Services	Energy, Mobility and transport, Telecommunications, Education, Communal space: provide improved access and services?
Health	Water, Sanitation, Waste, Drainage, Healthcare, Shelter, Nutrition: provide improved access and services?
Vulnerability	Climate change resilience: project considers long and short term impacts of climate change? Location and environmental resources: hazard assessment conducted? Physical exposure and shelter: project impact on exposure of local communities to hazards? Institutions and social networks: project improves local linkages between communities and governmental institutions and services? Access to livelihoods and finance: project improves access to financial sources

Annex 4: Assessment Questionnaire Template

ASSESSING CRITICAL ASPECTS

Rating: 0 not applicable 1 NO, 2 RATHER NO, 3 RATHER YES, 4 YES

Institutional and legislative aspects

QUESTION	YOUR ANSWER	rating
Are adequate policies and legislation in place and implemented to support the operation and existence of the case?		
Does the case comply with environmental standards and regulations concerning emissions to the aquatic environments, soil and groundwater?		
Does the case comply with quality standards of service and/or product as defined by legislation, standards and regulations?		
Is the case endorsed by, and does it obtain support by local and national authorities?		

Rating: 0 not applicable 1 NO, 2 RATHER NO, 3 RATHER YES, 4 YES

Organizational aspects

QUESTION	YOUR ANSWER	rating
Does the organization have a clear organizational status (formal or informal enterprise, NGO, CBO, cooperative)?		
Does the organization have a clear and viable business model and plan, independent of its organizational form or affiliation and manage the project with responsibility, accountability and transparency?		
Does the organization have dedicated talented leadership and dedicated skilled staff?		
Are employee contracts attractive and conform or exceed to national and labor union recommendations (e.g. minimum salaries, work contracts, benefits, social security, insurance, etc.)?		
Does the organization interact successfully with other stakeholders in the system to structure and maintain a successful cooperation?		
Does the organization maintain a data monitoring system or benchmarking to evaluate performance?		

Rating: 0 not applicable 1 NO, 2 RATHER NO, 3 RATHER YES, 4 YES

Financial and economic aspects

QUESTION	YOUR ANSWER	rating
Is accounting and regular financial analysis an important part of the organizations operations? This includes if breakdown of cost components is available and if there is regular monitoring and evaluation of cost effectiveness.		
Is cost recovery of the project (revenues) viable and sustainable? Do revenues outweigh the cost? Are depreciation reserves to renew equipment available and capital costs/ repayment of loans ensured?		
Does and can the project obtain access to capital (financial loans from different sources, e.g. banks, government, development agencies)?		

Rating: 0 not applicable 1 NO, 2 RATHER NO, 3 RATHER YES, 4 YES

Technical aspects

QUESTION	YOUR ANSWER	rating
Is the technology appropriate and appropriately designed to operate under the local physical (e.g. climate, topography) and/or infrastructure conditions (e.g. roads, power supply)?		
Is there sufficient local availability of know-how and experience (skills) to design and build the technology? Ideally construction would be possible with local available material resources.		
Is there sufficient local availability of know-how and experience (skills) to operate the technology? This includes it the employees & operators working with the technology been sufficiently trained?		
Can the technology be maintained and repaired easily by the staff? If not, is there an existing supply and service chain established that can do this timely and at an affordable cost?		
Can the technology easily cope with and adapt to changing conditions (e.g. amounts or characteristics of waste)? If the technology be easily replicated and/or modularly up-scaled, this a sign of flexibility and adaptability.		
Has the most cost effective technology been selected for the project?		

Rating: 0 not applicable 1 NO, 2 RATHER NO, 3 RATHER YES, 4 YES

Health and environmental aspects

QUESTION	YOUR ANSWER	rating
Does the case prevent nuisances like bad smell, dust, noise and insects/animals?		
Does the case safeguard workers' well-being and health?		
Does the case safeguard community well-being and health?		
Does the case contribute to recovery and recycling of waste materials?		
Does the use make an effort to minimize use scarce natural resources or polluting energy sources? Ideally the case recovers energy from waste to reduce its own consumption.		

Rating: 0 not applicable 1 NO, 2 RATHER NO, 3 RATHER YES, 4 YES

Social aspects

QUESTION	YOUR ANSWER	rating
Do beneficiaries (residents or local authorities) regard the case as socially beneficial and are they supportive to the project?		
Does the project empower local structures (development committees, user groups, consumer associations and elected representatives, etc.) and provide direct or indirect local employment opportunities?		
Does the project provide equitable service or products, which also addresses the needs and potentials of the most vulnerable and marginalized groups of society?		
Is community participation/involvement considered and implemented in the project?		

Development of critical aspects over time

QUESTION	YOUR ANSWER	rating
How have the aspects evolved over time (favorable or unfavorable)? How are the future perspectives in this regard? Is there anything the project team is doing to foster a future favorable development?		

Annex 5: Determinants of sustainability in solid waste management – The Gianyar Waste Recovery Project in Indonesia.

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Annex 6: Determinants of resilience in community-led waste management

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Determinants of resilience in community-led waste management

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Abstract
Self-help by individuals and local community groups in solid waste management is widespread in cities of the developing world as coping strategy to overcome the lack of public services. The study identifies and analyses the driving forces, factors of sustainability as well as internal and external factors which influence failure or success of solid waste community-based initiatives in India. The ability to reflect on the situation, to judge existing risks and to trust in the capability to master the risks of everyday life in interaction with other persons and organizations forms the framework of analysis as core of "social and individual resilience". The concept of resilience is used together with the sustainable livelihood framework for the analysis of eight South Indian community-based solid waste schemes. The results clearly underline the importance of the human and social capital that an individual "instigator" brings into the initiative and highlights the importance of a "champion" in every successful initiative

Keywords: *Developing Countries; Waste Management & Disposal, Sustainability*

Introduction

Rapid growth of cities, increasing urban population density, increasing incidents of poverty, and the limited capacity of municipal authorities have a severe impact on urban environmental services in developing countries. Such lack of basic services, which includes excreta management, drainage and solid waste collection services poses a health hazard for residents and constitutes a major environmental threat. Chronic health hazards by inadequate hygienic conditions not only directly affect the poorest fraction of the population but also severely impact on public goods such as air, water and soil, thus affecting the rich as well as poor. Such a situation is an main obstacle to poverty reduction and the advancement of human dignity (WHO et al., 2000, Beier et al., 1976). As a response to malfunctioning municipal services, self-help initiatives by individuals and local community groups is widespread in cities of the developing world (Anschütz, 1996). In the 90ies community-based management was regarded as the key solution to improve urban environmental sanitation and much international support was given to strengthen such initiatives. Still today this approach shows signs of success, where the poor are no longer the targets of externally designed and directed initiatives but the agents of poverty reduction (Satterthwaite et al., 2011).

Indian municipalities, similar to many others in developing countries, are also finding it difficult to keep up with the pace of the rapid urban growth and are most often incapable of ensuring services let alone planning and dealing with the multitude of challenges of slums and informal settlements (Satterthwaite, 2005). As in many other developing countries however some 75% of the Indian urban citizens live in the bottom income segments, earning an average of 80

rupees (around 1.80 USD) a day (Sankhe et al., 2010), and most often live in informal settlements where precarious living conditions prevail. Also in India self-organised local solid waste management (SWM) initiatives are a good example of coping mechanisms which grow out of such malfunctioning municipal services (Zurbrügg et al., 2004a). Many initiatives are supported with knowledge and funds by local, national or international NGOs or other international agencies (Pfammatter and Schertenleib, 1996). However experience shows that external financial and technical support alone does not guarantee success (Ali, 2006). Many schemes failed soon after support phased out and even self-organised , bottom-up schemes in solid waste management which are not dependant of external funding tend to stop operation after a few years. The lack of coordination and interaction with the responsible authorities severely endangers the sustainability of many initiatives especially in solid waste activities, where coordination and collaboration with the authorities is most often required for secondary collection and disposal (McGranahan et al., 2001, Zurbrügg et al., 2004b).

This paper aims at identifying and analysing the driving forces for community-based initiatives in solid waste management. Furthermore it analyses internal and external factors which influence failure or success of such coping mechanisms. The analysis is based on results of a survey conducted at eight Indian community-based SWM schemes (Zurbrügg et al., 2004a). Assumption is that initiatives are fuelled by a motivation and capacity to tackle the risks of deficient solid waste management infrastructure and services and that the individuals or groups avail of the capability to initiate and sustain - in interaction with other persons and organizations - coping mechanisms to deal with this risk. Individuals or group of persons may use different means to cope and achieve improvement. Knowledge, interaction and communication, access to social networks as well as financial capital are typical examples. To help describe the access to resources and means to cope, this paper uses the sustainable livelihood framework approach and its structure of “assets” and “transforming structures and processes” (DFID, 1999).

Research Materials and Methods

Urban dwellers in developing countries are exposed to various environmental hazards in their daily life which are particularly enhanced by the urban dimension. Typically improved security and improved environmental sanitation services - particularly solid waste management - are often considered high priority in urban settlements. This retrospective analysis of a survey of Indian community initiatives in solid waste management applies three different conceptual approaches to describe how motivation, social capacity and access to assets influences community initiatives and how these elements affect sustainability and success.

Protection Motivation Theory

Understanding the willingness and ability of individual or groups of people to act or not, in order to protect themselves from deficient urban environmental services such as a lack of solid waste and its hazards is complex. Protection Motivation Theory (PMT) (Rogers, 1975) reflects a theory of persuasive communication, emphasizing the cognitive processes that mediate behavioural change. PMT proposes that the intention to protect one-self depends upon four factors: (1) the perceived severity of a threatened event; (2) the perceived probability of the occurrence; (3) the perceived response efficacy; (4) the confidence in one’s ability to undertake the recommended behaviour. Semi-structured interviews conducted with the initiators of the community-based initiatives were analysed in in light of these four factors.

The Resilience Concept

Deficient urban environmental services and resulting sanitation or solid waste hazards gives rise to a more or less chronic crisis and therefore a constant threat to the inhabitants. Persistent hazard and chronic threat to health and wellbeing can however also show intensification over time as the environmental system deteriorates further. The World Disaster Report 2004 claims that everyday threats are of greater concern than massive disasters (International Federation of Red Cross and Red Crescent, 2004). The analysis of such hazards and threatening conditions and its effects on people is commonly used to describe the vulnerability of individuals or groups. Moser (1998) defines vulnerability in the urban context as "insecurity in the well-being of individuals, households and communities in the face of a changing environment and their responsiveness and resilience to risks that they face during such negative changes". In contrast to vulnerability, resilience can be described as the means people have to cope with or even influence their environment. This ability of an individual or group of persons to reflect on its situation, to judge existing risks and to trust in the capability to master the risks of everyday life in interaction with other persons and organizations forms the core of "resilience" (Obrist et al., 2010). In the urban context, community resilience can be described by the availability of self-help actions initiated either by individuals of community groups and - more importantly - sustained by the community as a whole with the objective to react to a precarious situation and try to organise themselves and act in order to improve their local situation. Such resilience shows the following attributes: proactive behaviour, social learning, flexibility in actions and social acceptance. These characteristics can be regarded as personal or group assets which are available and can be used. This understanding of assets links to the sustainable livelihood framework approach.

The Sustainable Livelihood Approach

The sustainable livelihoods framework (SLF) is a way to enhance the understanding of livelihoods, main factors that affect livelihoods and the typical relationships between these factors. At the center of the framework, closest to the people, are the livelihood assets or capital which they have access to and can use. These are natural assets, human assets such as skills, education knowledge, capacity, and health, economic assets, physical assets such as technologies or infrastructure and finally social assets such as networks of social support. The extent of access to these assets is strongly influenced by a vulnerability context and by the prevailing social, institutional and political environment also called the "transforming structures and processes", which affects the ways in which people can combine and use their assets to achieve their goals (DFID, 1999, 2001).

Data availability

All data derives from interviews conducted during the research project "Decentralised Composting in Indian Cities" (Zurbrügg et al., 2004a) The goal of this project was to determine the success factors and obstacles of decentralised solid waste collection and composting schemes in order to define new strategies for supporting such schemes in future. India was chosen for this study as it has a very active composting scene comprising commercial enterprises, public organisations and community initiatives. Twenty composting schemes of different size, organisational set-up and scope were interviewed. The semi-structured interviews addressed organisational, technical, financial and social issues in order to draw a full picture of each scheme. As the survey covered not only questions to assess the current status of the composting scheme, but also the start-up process and future prospects as perceived by the interviewed persons, it was thus possible to retroactively analyse the collected data with a new focus resilience, on the five assets of the SLF,

and the four factors of PMT. Out of 20 solid waste management schemes, the analysis of this paper concentrates on eight community-based schemes, three each in the cities of Bangalore and Mumbai and one each in Chennai and Pune.

Results and Discussion

Overview of community schemes

The eight decentralised composting schemes can be distinguished by their aim, their scope of activity and the economic classification of the neighbourhood. Table 1 gives an overview of the eight schemes included in the analysis.

Reasons for taking action to improve the immediate environment

House-to-house waste collection service is generally not available in Indian cities. The household members are requested to bring their waste to the nearest collection point, which can consist of an open area with or without some constructed enclosing barrier, or else a designated container. In principle the municipal collection authorities should ensure that these collection points are regularly emptied and the waste is transported to the disposal site. However, the malfunction of public or even private services leads to unbearable environmental and hygienic conditions in the housing areas. Waste bins overflow regularly as municipal authorities cannot provide regular secondary waste collection service. The more unhygienic the collection points are, the less people tend to use them correctly or use them at all. This enhances indiscriminate dumping and unhygienic situation in the whole neighbourhood. As community members do not trust in the situation to improve in the near future, the detrimental hygienic situation puts much pressure on the residents to become active if they want to see any improvement. With regard to protection motivation theory (PMT) and the four factors that mediate behavioural change, results of interviews show that all respondents highlight the hygienic and environmental crisis in their neighbourhoods and the perceived health threat of this situation (1: the perceived severity of a threat). Quotes: “It was born out of a crisis. The local contractor was not emptying the bins in the neighbourhood properly. The community then decided to take over the waste management themselves” (Bangalore-1); “Out of a desperate need to keep the colony clean we organised waste collection and initiated composting” (Pune-1). In one case (Mumbai-3), it was mentioned that it was one individual that made the others in the neighbourhood aware of the threat which then led to action - “Waste was thrown out in front of the houses before people were made aware of the hygienic problem by a (female) bank officer living nearby”. However no information could be obtained on the perceived probability of hazard occurrence and no specific incidences of health impact were mentioned which might have led to the action. Additional reasons for sparking the initiatives were also identified. Especially the examples of Mumbai grew from environmental awareness and the wish of the residents for a strengthened public responsibility and street beautification within the neighbourhood. Solid waste management was only one among several issues tackled by the initiatives. In the context of PMT this links to the perceived response efficacy and the confidence in one’s ability to make a change: “Solid waste management is part of our street beautification programme in order to maintain the streets clean. We thrive for more environmental awareness and social responsibility among neighbours and especially our children” (Mumbai-2). Another similarity of the schemes is the number of households connected to one scheme. With the exception of the inception phase, where they started small and then grew to include residents of the neighbourhood, the initiatives then remained more constant in number of households served , as shown in Table 1. With the exception of two initiatives in Bangalore, all others serve less than 500 households. Size of an

initiative is influenced by the perceived or effective feasible outreach into the neighbourhood, or by the expected decreasing response efficacy if too many residents are involved.
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Table 21 Overview of analysed community-based solid waste management schemes

Case	Aim of initiative	Scope of activities	Economic classification
Bangalore-1	Improving cleanliness by solid waste collection in the neighbourhood.	180 households. House-to-house waste collection and composting as a means of waste reduction.	High income area, spacious properties and open public spaces.
Bangalore-2	Improving cleanliness by solid waste collection in the neighbourhood and beautification of public spaces.	3826 households divided in three organisational units. House-to-house waste collection and composting for waste reduction.	middle income area with mixed housing pattern.
Bangalore-3	Improving cleanliness by solid waste collection in the neighbourhood.	1200 households. House-to-house waste collection and composting for waste reduction; regular lectures on environmental issues.	Middle-high income area, partly with spacious gardens.
Chennai-1	Improving cleanliness in neighbourhood, raising environmental awareness and community mobilisation.	476 households. House-to-house collection of segregated solid waste, street sweeping and composting.	Lower-middle income area, dense housing and apartment buildings.
Pune-1	improvement of cleanliness of neighbourhood and waste reduction to avoid overflowing municipal bins.	264 households. House-to-house waste collection, street sweeping.	High income housing communities with spacious garden and public places.
Mumbai-1”	Community mobilisation and increasing social cohesion. Neighbourhood beautification, increase of environmental awareness and well-being of inhabitants.	125 households. Waste segregation at source, house-to-house waste collection, street sweeping, public safety through street lighting, monthly rallies, annual environmental clean-up campaigns.	Middle income area.
Mumbai-2	Community mobilisation and increasing social cohesion. Neighbourhood beautification, increase of environmental awareness and well-being of inhabitants.	120 households. Improved solid waste collection for street beautifications and composting. Compost used for new flower pots in the streets. Painting of walls.	High-middle income area, houses with small gardens.
Mumbai-3	improvement of hygienic condition within the slum	350 households solid waste segregation, composting, households voluntarily deliver waste to the composting site and the municipal public bin	informal settlement lacking infrastructure, community densely populated with simple houses or huts, located in an old stone quarry

The more residents are involved, the larger the complexity of interaction becomes and more difficult it is to achieve social cohesion and consensus within the group. The scheme Bangalore-2 which extends its outreach to over 3800 households is an exception as it is led and supported by a local NGO – with more and more skilled available human resources and supporting funds. Bangalore-3 on the other hand developed a decentralised structure with sharing of key responsibilities among sub-groups in the neighbourhood from the outset of the self-help initiative. Except for one initiative (Mumbai-3) all initiatives are located in middle- to high-income areas. This might be due to a bias in selection of identified schemes as the local experts only had knowledge about the existence of these initiatives. However, it nevertheless becomes clear that more affluent areas show certain typical asset patterns which suggest that the existence of community-based initiatives is closely linked to available assets.

Livelihood assets as determinants of resilience

The eight initiatives were further analysed based on the five asset categories of the sustainable livelihood framework.

Human Assets – knowledge & skills

Knowledge or a high level education is an asset of almost all persons initiating such activities. The knowledge can be distinguished into the two levels: (a) societal awareness and (b) technical knowledge. The majority of the initiators of composting schemes hold a university degree which is most interestingly a degree in natural science or technology. It can therefore be deduced that the knowledge of natural and technical processes encourages initiators to start a rather technical oriented service such as composting or community-based waste collection. Many initiators are interested in the biological processes of composting and carefully observe and conduct detailed monitoring or optimise their composting heaps as a hobby. They furthermore also show skills in construction or in planning to optimise waste collection vehicles or composting bins. Even the case of the low-income area of Mumbai-3 shows that a teacher was the main driving force to maintain the composting site and the entry point was by starting planting trials with vegetables on compost. Motivation and dedication to the improvement action is thus often fuelled by the knowledge a person has, or the interest in enhancing and gaining more knowledge on this specific aspect. It is thus the resilience of an individual taking action inside the community which is decisive. Community (group) resilience is less relevant in the stage of inception.

The knowledge and experience from other urban areas and their respective living conditions is also a driving force, which can lead to action. Two interviewed initiators of initiatives (Bangalore-1 & 3) mentioned that they have been working abroad in America and Europe and that they had appreciated the cleanliness there. After their return they were motivated to maintain their neighbourhood as clean as they had experienced abroad. They have a clear vision about what a neighbourhood could or should look like. After realising that the municipal authorities could not deliver this envisaged service they decided to become active themselves.

Conflict resolution, communication and management skills of the core members of the initiative are crucial to maintain motivation and participation of households. Inspired by a leadership course, the initiator of Bangalore-3 motivated the neighbours with the following principle: “we are rather celebrating achievements than blaming shortcomings”. Furthermore, he stated that each person brought in his or her own skills for the management of the community SWM system.

Human Assets – dedication & time

The analysis further revealed that dedication and time are two important assets for the start-up of

community-based SWM and composting schemes. All work and commitment of the initiators and supporters of the reviewed initiatives to improve the situation is done on a voluntary basis or by a small payment which is significantly lower than in other fields of work. This clearly shows the dedication of these individuals to the cause rather than interest in the salary. But also time seems to be another important asset. Many residents involved are ladies without formal employment but dedicated to social work and their household and neighbourhood surroundings. Analysis also shows that many retired persons started the initiatives to improve the cleanliness in their neighbourhood.

Social Assets - network within the community, trust and reputation

The social network within a community shows to be crucial for the motivation of residents to cooperate as a community to improve SWM through a collection and composting system. All initiatives have in common that the initiator is a well-respected person in the community. This respect stems from the professional rank, political involvement or social activism and links to reputation and trust. In several cases the interviewees mentioned the importance of trust. The following examples show, that particularly women are trusted when it comes to financial issues: “leading ladies, who enjoy the confidence of the community collect the waste fees” or “one trustworthy lady is collecting the fees monthly”.

The initiators also see themselves in a leadership role inside the community which can be drawn from the following quotes: “Leadership is not power but the opportunity to serve” or “The first chairwoman was active in local politics and had a sense for social issues. Social control was working as long as a strong leader was present. Now that she has withdrawn, households fall back to old habits”. These leaders are able to establish alliances with friends and neighbours and define a common vision for the local SWM and composting project. Frequently project meetings and encounters are held at the private residence of this leader and initiator.

Special cases are the initiatives in Mumbai. As they were all developed with help of a semi-formalised structure provided by the municipal authorities. These initiatives are targeted towards community management as a whole where SWM is only one among several technical and social topics. This semi-formalized setup has been able to established strong social cohesion in some neighbourhoods, which then shows significant benefits for the public space. When little support is available from “structures” (institutions) then the resilience aspects of the individual (particularly of the leadership) plays are critical role as it is this person which pulls the strings and overcomes barriers. If this person then leaves, for whatever reason, survival of the initiatives can be severely endangered unless the leader has been able to find an appropriate replacement with similar assets. When, as in the case of Mumbai, the municipal authorities support the local initiatives in different ways, then it is rather the community resilience, social capital and sense of cohesion that plays an important role. In such cases “individual” resilience is less critical.

Social Assets - link to external agents and organisations

All respondents mentioned their need of support by other stakeholders or institutions that facilitate the community action through an enabling and supporting environment (in the sustainable livelihood framework this is summarized under “transforming structures and processes”). This is also confirmed by an analysis of Colon and Fawcett (2006) in Chennai highlighting the need for local resources, political, technical support and strong local leaders. Several schemes complained about insufficient support or even a jeopardising role of municipal

officers. Such statements - particularly from low-income groups - show how motivation is inherently linked to coordination and exchange of the community with official entities. People feel supported and feel their work acknowledged if the local government authorities show signs of recognition. In the cases of Mumbai - where municipal authorities offered a general clean-up of the area with heavy equipment (e.g. front loader and trucks to clean up illegal dumps) in exchange for the communities commitment to care for neighbourhood beautification and payment to street sweepers or local waste collectors - the municipal officer is perceived by the community as very dedicated to the job: "people listen to him as representative of the municipality". Such support can also entail connecting the community to other external actors. Mumbai-1 for instance stated that they were inspired by the achievements of other community initiatives which were highlighted to them by the municipality. The initiative of Mumbai-2 established a link to a waste-picker association for the recruitment of reliable labour for their initiative. Others also take advice from time to time for technical matters from research institutes or private companies in the form of a consultancy service.

In summary the analysis shows that links to municipal authorities, NGOs, research institutes or even private businesses are very supportive in different ways. Firstly, they allow the recruitment of (suitable or qualified) workers for the scheme (waste-picker associations), secondly they can enhance knowledge transfer and networking, thirdly these connections and contacts provide potential opportunities for accessing funding sources for initial investments and finally, fourthly, they can strengthen visibility and acknowledgement by authorities. Particularly this last aspect is considered a key factor for the long-term success of a community SWM schemes as a link to the formal responsible authority is essential.

Natural Assets – access to waste

Major natural asset for SWM and composting schemes is the access to waste, which of course is given in all cases. Access to waste might however change over time. When municipal strategies start to involve private sector for service delivery, they will compete with existing community-based collection initiatives. Given that this "new" service might even be free of charge the community initiatives are bound to stop functioning although service level may not necessarily improve. This perceived threat was reported in the case of Chennai.

In community composting, the quality of waste plays an important role as composting initiatives require segregated biodegradable waste to achieve high quality compost. Hence, the initiative needs to motivate and engage households to segregate their waste at household level in two fractions: wet biodegradable waste and dry recyclable waste. In the interviews motivation and cooperation of households is stated as something which is difficult to achieve and requires the initiator and social mobilizer to have excellent communication skills and be highly respected by the residents. Thus the aspect of social group peer pressure seems critical here where residents do what they perceive is expected from them by their social network. This example shows how closely natural assets and human and social assets are linked. Access to waste might however change over time.

Further examples for natural capital are the access to water and access to additives for composting (e.g. cow dung). Water is a crucial input material for composting and difficult access was mentioned as an obstacle in almost all cases. Only two schemes have access to a groundwater source or a tap. The availability of cow dung strongly depends on the financial assets, as in an urban setting cow dung needs to be purchased.

Financial assets – investment capital and recurring costs

Raising and managing financial capital is a major challenge in all assessed initiatives. Firstly, the schemes require money for the initial investment for infrastructure (collection carts, compost boxes, tools), secondly, recurring costs need to be covered continuously by regular revenues. In high income areas the initial investments were less critical, as often the initiators invested their own money or used their social network to raise money for infrastructure and equipment. In Mumbai-2 for example, after a general clean-up the initiator was able to win a local music store to fund new flower pots as well as the compost bins. None of these initiatives analysed had any access to loans. In the case of Bangalore-2, the NGO involved provided grants for the purchase of land or construction of infrastructure. In a few cases it was specifically mentioned that with the successful initial investment the collaboration of the residents then picked up. Once a first general clean-up was done and the infrastructure was in place, even hesitant households agreed to participate.

For the financial viability of a scheme, most respondents mentioned that acceptance and participation of all households is crucial. In all cases income from sales of compost or recyclables was low and does not cover the recurrent cost. Rather it is the regular waste collection fees paid voluntarily by the participating households which enables financial viability. Problems with fee collection and delays in payment however seems to be the norm. The following two statements illustrate these obstacles: “The richest are least willing to pay the waste management fee” (Bangalore-1) or “50 % are willing to pay, 40 % are reluctant and 10 % do not pay (Bangalore-2)”.

The larger an initiative is, the more professional it must act and the more dependent it becomes on the financial contributions of the households. All analysed initiatives depend on voluntarily paid fees and enforcement of payment is not feasible as these initiatives are informal organisational structures without a legal backing. The willingness of residents to pay is closely linked to the status of the person that is collecting the money. It shows that waste collectors, usually unskilled and uneducated labour and not well integrated into the social network, face difficulties if they need to ask for payments. They are not taken seriously, not trusted, and often also do not have the necessary self-confidence to put pressure on the residents to pay. On the other hand, “ladies” of the neighbourhood are usually welcomed into the house by residents and residents then find it embarrassing to haggle or refuse to pay such a small monthly fee. Finances must be managed transparently to maintain the trust and satisfaction of the participating households.

Physical assets – infrastructure and access to land

Particularly, infrastructure and land are key physical assets for community-based SWM and composting schemes. Although in the urban area there is usually not much open and unused land available, the analysis of these existing initiatives however shows that even smallest strips of land are made available and used for composting. In Mumbai and Bangalore for example compost bins were constructed on top of drains or under high voltage power poles. In two cases, space was made available for composting by clearing an illegal neighbourhood dump site. In these cases, the composting site was even more appreciated by the neighbouring households, as the nuisances of the dump was removed. The initiatives of Chennai and Pune own the land they use and Bangalore-2 obtained an official approval by the municipality to use open plots for composting. The other initiatives are set up on unused public land without a clear and formal permission by the municipal authorities. Such an informal status constitutes a high risk to sustainability as the initiatives have to continuously fear sudden eviction by municipal authorities. These risk are

somewhat averted by a strong social assets, i.e. good connections and relations to key people in municipal authorities or local politicians. It thus becomes evident how social assets are connected to availability and access to physical assets.

Conclusions

Assessments of strengths and weaknesses in solid waste projects often focus only on a physical, technical and financial description without taking into account the "human" factor (Ali, 2006). This analysis of community-based initiatives in solid waste management uses asset categories as defined in the SLF and provides useful insights on the necessary preconditions and strengthening factors for community resilience in the urban sanitation context. It can in fact be concluded that human and social assets are key to the success of all community initiatives. All interviewed initiators revealed that the task of starting such a community activity is not easy and takes a lot of effort. By taking action they expose themselves to the public and become a subject of discussion in the community. It is only thanks to special human and social assets that such a task is feasible. Strong leadership, communication and networking skills and high social recognition are key attributes of all initiators. As long as all members of the community participate and cooperate, such systems can sustain themselves. Nevertheless, given that neighbourhood primary collection systems always depends on a secondary collection - which entails regular emptying of a municipal collection point and transport to the disposal site – there is a need to coordinate and collaborate with the next higher level: the municipality. This interaction is also crucial when considering the informal status of such initiatives, always at risk of being contested or dismissed. It is again the strong social assets of core members such as good connections and relations to influential people or key people in municipal authorities which can avert these risks. These findings are confirmed by Colon and Fawcett (2006) which also highlight the need in community-based schemes for significant local resources and political and technical support which are hard to find and sustain without strong local leaders. This pre-condition of strong leadership influences the potential of replication of similar schemes. In Mumbai however, given the support and commitment of the municipality, replication of such initiatives is more obvious.

Understanding the drivers of such community-based actions and the assets required to maintain them, finally allows a better planning and development of more targeted support to such initiatives - either through direct support such as training or by indirect support in facilitating a better enabling environment at municipal or national level.

Community-based schemes in solid waste management exist and this indicates a certain level of resilience of communities and their ability to reflect on their situation, to judge existing risks and to trust in their own capability to master the risks of everyday life in interaction with other persons and organizations. Each individual resident has only a limited impact on cleanliness other than in the private sphere. The neighbourhood and public space can only be improved through collective and coordinated action by all stakeholders.

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DICHIARAZIONE DI CONFORMITÀ DELLE TESI PER IL CONSEGUIMENTO DEL TITOLO DI DOTTORE DI RICERCA

DICHIARAZIONE SOSTITUTIVA DI ATTO NOTORIO

ai sensi dell'art. 47 del D.P.R. 445 del 28.12.00 "T.U. delle disposizioni legislative e regolamentari in materia di documentazione amministrativa"

Dottorato di ricerca in : Metodologie e tecniche appropriate nella cooperazione internazionale allo sviluppo

Il/La sottoscritto/a…Christian Zurbrügg…… Nato/a il…Rangoon, Myanmar 19.12.1962.

a (indicare anche l'eventuale paese estero)…Zurigo, Svizzera……..

Provincia di (ovvero sigla del paese estero)…Zurigo, CH……

a conoscenza del fatto che in caso di dichiarazioni mendaci, oltre alle sanzioni previste dal Codice Penale e dalle Leggi speciali per l'ipotesi di falsità in atti ed uso di atti falsi, decade dai benefici conseguenti al provvedimento emanato sulla base di tali dichiarazioni,

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sotto la propria responsabilità, ai fini dell'ammissione all'esame finale per il conseguimento del titolo di Dottore di ricerca, di essere a conoscenza che,

in conformità al Regolamento dell'Università degli Studi di Brescia per l'ammissione all'esame finale ed il rilascio del titolo per il conseguimento del titolo di Dottore di Ricerca, è tenuto a depositare presso l'U.O.C. Dottorati:

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b) due copie della tesi su DVD o CD-ROM per il deposito presso le Biblioteche Nazionali di Roma e di Firenze ;

ad inviare il "questionario dottorandi" del Nucleo di Valutazione di Ateneo .

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E AMMINISTRAZIONI SONO TENUTE A PROCEDERE AD IDONEI CONTROLLI, ANCHE A CAMPIONE, SULLA VERIDICITÀ DELLE DICHIARAZIONI SOSTITUTIVE

The objective of this thesis is to provide support, with a set of assessment tools and procedures, for better planning, design, implementation and continuous adaption of waste projects in low- and middle-income countries. Following the analysis of current existing methods and tools for assessment, with their respective advantages and disadvantages, a simplified questionnaire-based tool was developed which captures the main determinants of success for development projects in solid waste. Results from case study analysis show that some common key features of successful solid waste management projects are frequently overlooked when planning projects. These are:

- Effective organizational structure: This entails having an organizational setup to operate the project; one that is clearly defined in its goals and objectives, has a strong forward looking leadership and skilled, motivated and continuously trained staff. The organization operates under the principles of entrepreneurship, commitment to a high quality of service, customer care, accountability, transparency, and equity.
- Viable business model and financially sound setup: This involves ensuring a well-developed business model and business plan, the capacity to mobilize investment capital and well-conceived sustainable mechanisms to recover capital and operational costs through reliable revenue sources over a long-term project period.
- Endorsement by government and compliance to legislation: This requires that the project is recognized by the government as an integral part of the overall strategy and is in accordance with national laws, regulations, standards and codes.