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CO	Confidential, only for members of the consortium (including the Commission Services)	

LIST OF FIGURES

ABBREVIATIONS

APE	Association for the Protection of the Environment
CDM	Clean Development Mechanisms
CER	Certified Emission Reduction
CFL	Compact Fluorescent light bulbs
CSO	Civil Society organizations
CSR	Corporate Social Responsibility
DSD	Duales System Deutschland
ISWM	Integrated Solid Waste Management
IWMP	Integrated Waste Management Plan
IWMSA	Institute of Waste Management n South Africa
IWWA	Integrated Waste Management in Western Africa
MRF	Material Recovery Facility
MSW	Municipal Solid Waste Management
NGO	Non-governmental organization
PPP	Private Public Partnership
RDF	Small and medium enterprises
SWM	Solid Waste Management
WEEE	Waste Electrical and Electronic Equipment

1. INTRODUCTION

This document is Deliverable 3.3 of Work Package 3, which is part of the project on Integrated Waste Management in West Africa. The aim of this task is to identify the most suitable Integrated Solid Waste Management systems (ISWM) and approaches for the four West African countries, Côte d'Ivoire, Ghana, Nigeria and Senegal. It systematically describes and evaluates ISWM practices in Europe that relate to logistical, technological, legal and organisational elements. Waste management practices in several African countries, which are typically less complex than in Europe, are also considered, focusing predominantly on the technologies and organisational practices that have been successful but also highlighting potential obstacles and pitfalls.

The most appropriate systems for municipal waste, organic wastes, electronic wastes and recyclable wastes are discussed in the light of the SWM capacity in the four West African countries, Ghana, Nigeria, Senegal and Côte d'Ivoire. A discussion on the selection of suitable technologies and institutional arrangements is forming is forming the basis of a guide that has been developed as a tool for selecting appropriate technologies for the four West African countries.

2. EVALUATION OF ISWM PRACTICES IN EUROPE

2.1. Evaluation and adaptation of practices from Germany

In this chapter, the technological and organisational practices described in task 3.1 will be evaluated and adapted, based on the technical and non-technical practices in Germany.

2.1.1 Logistical elements

In Germany, municipal waste is collected from the households and treated in central large-scale plants. There is a separate collection for waste paper, glass, biodegradable waste, "DSD" waste destined for the Dual System in Germany (mainly plastic packaging and metal cans) as well as other residual waste. This detailed separation leads to high volume of transport, which is probably not suitable for western Africa.

The collection of residual waste should be organized by the local municipalities. A separate collection is only useful if the different fractions are also treated separately. In rural areas, decentralised plants would be a way to reduce the volume of transport. In urban areas (mega cities) large scale plants will also be needed.

Possible collection fractions could be:

- Residual waste
- Recycling fractions such as glass, paper or plastic
- Hazardous waste such as old batteries and electronic equipment

Depending on the collected fraction, the collecting system can vary. For the residual waste, household or close to household collection is useful. Because of the odour nuisance from mixed residual or biodegradable waste, this fraction is not kept in the house very long. And as central collecting stations result in longer distances and therefore fewer visits, there are no useful alternatives for mixed residual waste to a collection frequency at least on a weekly basis.

For recycling fractions such as paper, glass and (clean) plastic, central collection points are appropriate. Deposit-refund systems, e.g. for bottles, would further increase the return rates.

Hazardous wastes such as batteries occur in very small amounts therefore household collection is not useful. They could be also collected in central collection points for recyclable fractions. Additional collection points in shops or other frequently visited places would increase the return rate and prevent them to be disposed together with the mixed waste fractions. In Germany, some schools provide collection boxes for batteries. This can be combined with a school campaign for environmental education.

2.1.2 Technological elements

In Germany, municipal waste is mainly incinerated or treated in mechanical-biological waste treatment plants. On a lower level, fermentation is also used for separately collected biodegradable waste from households and industry.

Incineration mainly of mixed residual waste is done in special waste incineration plants but also industrial incineration, mainly of separately collected high-calorific waste plants, in co-incineration plants.

Incineration depends on large-scale plants and high technical experience of the staff. The creation of the necessary infrastructure is time-consuming and costly, but nevertheless incineration needs to be taken into account for densely populated areas such as mega cities.

A separate waste incineration plant is one possibility, but co-incineration in industrial applications is also an option. Co-incineration in existing plants has the advantage that the technical equipment and qualified staff are already there. In both cases, flue-gas cleaning is necessary to prevent emissions of particle matter and pollutants damaging the health and the environment.

For more rural areas, small decentralised treatment plants would be a more suitable option. These would reduce the transport costs compared to bigger centralised plants and they would need less qualified staff. Depending on the climatic conditions, fermentation or composting of biodegradable waste should be considered. Both techniques rely on water availability and temperature. These plants produce fertilizer which can be used for agriculture. Fermentation plants produce biogas, which can be used for heating or power generation. Composting is possible in a highly decentralised way up to individual application.

Recycling is a key component of modern waste reduction technologies. In Africa, backyard recycling is commonly practised. The resulting experiences should be built upon but incentives for greater occupational safety and technical improvements are necessary. Large-scale recycling plants are not suitable as they would take away the financial basis for many backyard recyclers. Another problem, which occurred in large-scale plants in India, for example, is that there is no continuous flow of resources. Therefore, backyard recyclers would be better supported as small businesses. One possibility is to make loans available which are coupled with safety or technical obligations.

2.1.3 Legal and organisational elements

Like in all other EU countries, Germany has a framework law, which provides a "waste hierarchy" through

- Waste prevention
- Recycling
- Disposal

In Germany, citizens are obliged to dispose of their waste using the local waste disposal system. Waste charge regulations should reflect the amount of waste disposed to encourage waste prevention. Accordingly, waste fees vary considerably across Germany, although these fees are required to cover the costs of the disposal and a realisation of profits is not intended.

On the one hand, waste collection fees can be an element to encourage minimisation of waste while on the other hand, in countries where a structured waste management system is not yet established, they can also lead to further illegal dumping. For waste collection and treatment to be offered free of charge, however, "external" funding would be necessary. This is clearly not possible and so fees or taxes for waste disposal are unavoidable but must be adapted to the economic power of the consumers. For the success of a waste management system depending on fees/taxes, it is important that the consumers and producers understand clearly why they have to pay these fees and what they are used for. Therefore, information campaigns and environmental education are needed.

Regulations cannot consider every regional difference and characteristic, therefore a framework law which defines general rules and goals is recommended. Implementation should be left to the regional municipalities. By integrating industrial waste into the framework law, large amounts of waste are covered.

Summarized it can be stated, that waste management can only work where there is good awareness about the issue within the population.

2.2. Evaluation and adaptation of practices from Sweden (Denmark, Finland)

2.2.1 Logistical elements

Development of improved SWM systems does not necessarily mean motorization (UN-HABITAT 2010). While Sweden has motorized vehicles for all waste collection, non-motorized vehicles might be a more suitable choice for some West African areas taking into consideration the urban planning and economic situation, with lower labour costs than in Europe, but rather high costs of vehicle fuel.

Waste bins for the public should be more easily accessible in urban areas in Ghana and other West African countries. These bins can be provided by the municipality, or local waste management authority, which can employ the services of the private companies to collect them when they are full. This will help reduce the amount of littering in the cities. When waste is no longer disposed of in the streets the urban environment will be more aesthetically appealing.

2.2.2 Technological elements

Material recycling plays a very important role in the Swedish strategy to make use of waste and to close the environmental cycle. A deposit-refund system for glass and plastic bottles encourages citizens and informal waste pickers to return bottles. More than 90% of returnable drinking packages are returned and reused. These packages consist of aluminium cans, glass and plastic bottles.

Old batteries are environmentally very hazardous and should be collected separately to prevent batteries from ending up on a landfill. The Swedish system of having collection boxes for waste batteries located at grocery stores, schools and places where people often visit (Deliverable 3.1 report) can easily be adapted in West Africa. Having people sort their batteries can also be a start to encourage people to sort their waste.

2.2.2.1 Organic waste management

Decentralised composting at household level (home composting) has been successfully applied in many detached housed with gardens in Sweden. The food waste is composted with garden waste in a closed container and the compost is reused in the garden. The household usually gets a reduced waste collection fee. It would be a good idea to explore this technology in West Africa as well, since it is a good way to achieve reuse of food waste and organic matter and to reduce waste transport costs.

Sweden has gradually introduced biological treatment (composting and anaerobic digestion) of source-sorted biodegradable waste over a 20-year period. It is recommended that the West-African countries also develop separate treatment of biodegradable waste (see report from Task 3.2 for motivation) and, similarly to Sweden, adapt the technologies to their local circumstances. This will require a feasibility study that determines waste composition, labor market, urban infrastructure, market for compost and other fertilizer products. In this development, it is necessary to build technical competence in cooperation with research organizations. Importing turn-key facilities from other countries without building local competence is bound to fail, as has already happened in West Africa and in other parts of the world.

2.2.3 Legal elements

The environmental aspect of waste management is a broad category and the main driver for sustainable waste management. Not only the environmental factors which contribute to global

warming are important but also the cleanliness of the local environment kept litter-free because waste is disposed of in a proper way. In both Sweden and Ghana the waste hierarchy; reduce; re-use, recycle and dispose are important factors when planning waste management. Both countries have adopted the waste hierarchy in their legal framework (3.1 report: National Environmental Sanitation Strategy and Action Plan 2010). As early as 1960 Ghana implemented a law against illegal dumping around the same time as Sweden put more emphasis on stricter waste management laws in order to protect the environment, moving away from the practice of dumping most waste in landfills to recycling and incineration. The main difference was that Sweden made sure the laws were fully implemented and followed up, but Ghana did not. In order for waste management to be sustainable, the existing national and local waste management laws must be fully implemented, financed and enforced.

2.2.4 Organisational elements

Organizational aspects go hand in hand with technical and legal issues, so some organizational aspects of waste management in Sweden are of relevance for West Africa.

2.2.4.1 Waste management planning

Waste management plans at national and municipal level have been an essential part of Sweden's development from being a landfilling to a recycling nation. This change affects the whole society, from every household to the whole waste management industry. It is inevitable, that this process takes time and involves long-term plans that set step-wise targets and priorities and identify problems that need to be solved.

Waste management plans, which describe the current situation, set goals for a 5-10 year time frame and identify actions needed as well as resources required to reach these goals, are a very effective tool for communicating gradual improvement in waste management practices to government organizations, politicians and external stakeholders.

2.2.4.2 Economic incentives for waste reduction

Waste collection fees have been designed to encourage minimization of waste and source-separation of waste. Many municipalities offer bins of different sizes and different collection intervals, with lower fees for households that produce less mixed waste, practise source-separation or do home composting.

2.2.4.3 Waste management association

Having a national Waste Management Association, an institution for cooperation between municipalities, which also provides links between researchers and practitioners, has been very important for disseminating best practices among different municipalities in Sweden (Deliverable 3.1). An association of this kind should be relevant for the West African countries. It will serve as storehouse for information on waste management as well as organize training programs for role players in waste management.

2.3. Evaluation and adaptation of practices from Switzerland

2.3.1 Logistical elements

Lessons learnt in solid waste management in Switzerland show that a clear assignment of responsibilities among national, regional and municipal authorities, private sector organizations and individuals has proven to be the key factor of success. However, waste planning in West Africa is facing some other realities, the most restrictive of which is probably trying to achieve the most with the limited funds available to the waste service. Improvements are not necessarily dependent on massive investments; target countries can probably increase their performance by using what they already have in a more efficient way. With that purpose, main aspects of Swiss logistical practices in SWM are assessed below in the light of their feasibility for the target countries of IWWA project (Côte d'Ivoire, Ghana, Nigeria and Senegal):

Household waste in Switzerland in most cases is collected on a weekly basis by the public waste collection schemes which in towns are mostly operated by the municipalities, whereas in rural

areas they are operated by private transportation companies mandated by the municipalities for this service. In West Africa, it is necessary to adapt collection frequency to waste generation and overall efficiency of the system. It is therefore necessary to gather data on waste generation and composition, area characteristics, haul distances, availability of spare parts and service facilities.

In Switzerland metals, glass and plastics (PET) are collected free of charge at municipal waste collection drop-off sites. Most municipalities provide a monthly or bi-monthly door-to-door collection for paper, cardboard and textiles. Due to the weaknesses of the decentralization process in the target countries, this system of free collection by municipalities would be difficult to apply unless municipalities have enough funding and skills to be in charge of the collection. Another option is for the private sector to take care of door-to-door collection and guarantee the separation of recyclables wastes. The informal sector could be promoted to work in better conditions and be responsible for this task. Likewise, households can be encouraged to separate at source by means of education and economic incentives. Civil Society Organizations (CSOs) should collaborate with local authorities to raise awareness and develop information campaigns that aim to effect behavioural change on waste sorting. This would be supported by disseminating training material such as technical guidelines for waste reduction and prevention.

Biodegradable waste collection is offered in Switzerland by some town municipalities. The quantities of separately collected biodegradable waste is increasing, however not all towns provide this service due to the additional costs of a separate collection and other potential disturbances that it might cause at the collection points. For the target countries, biodegradable waste should be processed as far as possible in a decentralized system utilising low-cost solutions. Large-scale composting plants which are used in Europe do not seem appropriate for West Africa. The collection and transportation of organic waste to centrally managed sites is expensive, time consuming and energy intensive; these processes are also often dependent on fossil fuel inputs although MBT options increasingly include electricity generation from this renewable energy source

According to the Swiss experience, waste generated by industries or complex waste streams like Waste Electrical and Electronic Equipment (WEEE) can be better managed by the producer of the waste than by government bodies. This experience could be applied through legislative instruments in West Africa together with law enforcement. The polluter pays principle and the Extended Producer Responsibility concept should be followed as much as possible with the government setting clear framework conditions under which the responsible bodies have to act. Waste disposal costs should reflect real costs and include, for example, aftercare costs for landfills and operation of recycling services. Prices for waste disposal should incentivise recycling and source separation at household level.

2.3.2 Technological elements

2.3.2.1 Separation and pre-treatment

Separation of household waste and recyclables like metal, glass, paper, cardboard, PET and textiles is done at household level in Switzerland, authorities provide with waste bins for separation. It would be recommendable that West African authorities also provide households with specifics containers and guidelines for appropriate waste sorting.

Mechanical-biological pre-treatment of household waste prior to incineration or final disposal is not done in Switzerland since the higher quality of organic waste for energy valorization without pre-treatment is prioritized over the reduction of volume achieved by pre-treatment. For West African countries, the choice of mechanical pre-treatment could be of interest since these plants reduce waste volume. Nevertheless, when organic waste treatment is considered for these countries a system without mechanical pre-treatment should also be one of the options.

2.3.2.2 Recycling and recovery

Lessons learnt in Switzerland show that waste recycling activities and reintegration of secondary resources into new products should take into account the potential of cross-contamination. Plastics from WEEE in many cases are not suitable for reintegration into new plastic products due to their high content of heavy metals and brominated flame retardants. Plastics recovered from mixed

waste could also be potentially contaminated with toxics. Mechanical treatment of waste when not done properly also has the potential for cross-contamination of secondary goods.

WEEE contains hazardous but also valuable and scarce materials, being a potential source of income for the target countries however, recycling and disposal of WEEE may pose a significant risk to workers and communities. Great care must be taken to avoid unsafe exposure to hazardous substances in recycling operations and leaching of material such as heavy metals from landfills and incinerator ash.

2.3.2.3 Final disposal

The Technical Ordinance on Waste of Switzerland (TVA) specifies rigorous requirements for waste that is to be landfilled. This is in contrast to the majority of landfills in West Africa which are open dumps. Often a lack of financial and human resources, coupled with a lack of enabling policies, limit the extent to which landfills can be built, operated, and maintained at minimum standards for sanitary practice. It is then necessary that African authorities provide appropriate equipment or other resources to carry out these practices. There are three types of landfill in Switzerland:

1. Landfill for inert materials, which do not require any special sealing. They are thus less costly and require less monitoring than other types of landfill.
2. Landfill for stabilized residues with high concentrations of heavy metals and only a small organic component, and which cannot release either gases or substances readily soluble in water. These sites are subject to more stringent requirements than landfills for inert materials. Impermeable linings are required for the base and sides of the landfill, and leachate must be collected and, if necessary, treated.
3. Bioactive landfill: All other types of wastes suitable for landfill have to be disposed of at bioactive landfills, in which chemical and biological processes are expected to occur. At these sites, drainage controls are also required. In addition, any gases emitted are to be captured and treated. Given the unpredictable composition of their contents, bioreactor landfills are at the greatest risk of requiring expensive remediation at a later date.

Furthermore, in Switzerland there are 29 municipal solid waste incineration plants all of which use the calorific energy of the waste for producing heat and electricity. The waste incineration plants nowadays provide about 2% of the final energy use in Switzerland.

Use of incinerators could have several advantages in the target countries in that incineration plants can generate electricity and heat that which substitute power plants powered by other fuels. However the negative impacts of their use in West African countries should be very carefully weighed up before choosing this technology because incineration is an expensive method that destroys resources and the waste in the target countries is often too wet to be incinerated efficiently. The health effects of emissions (e.g. dioxin and furan) must also be taken into account because these can only be significantly reduced by including new advances in emission control designs and very stringent governmental regulations.

2.3.3 Legal elements

The Federal Law on the Environment of Switzerland establishes the polluter pays principle, the precautionary principle and the principle of reduction of emissions at its source as guiding principles. In Africa, these principles have been introduced only recently, and many industries are not in a position to make the radical changes necessary to apply them because of the lax pollution controls of the past, which allowed practices, technologies and equipment that had limited pollution control mechanisms. Clear strategies and action plans should accompany the existing regulatory measures in order to move forward to more sustainable SWM practices. Wastes generated by industries or complex waste streams like Waste Electrical and Electronic Equipment can be better managed by the producer of the waste than by governmental bodies

The participatory approach of developing Swiss legislation regarding SWM is a valuable lesson learnt and which is relevant for West Africa. In the target countries, there is a need to involve all stakeholders through participatory processes in the development of legislation and Action Plans in

order to consider the different roles and interests in the waste management chain. Action Plans must assign responsibilities and resources to perform the necessary tasks.

Furthermore, legislation in the target countries must be adapted to local circumstances. There are problems of inequity depending on rural, urban or peri-urban areas, likewise religion, culture, or language differences make it difficult to apply same measures consistently to the whole country. The experience of Switzerland in decentralization can be very valuable.

Even though there is a proper legislation in the target countries, compliance with the law is very weak. The lack of law enforcement is one of the main shortcomings in the target countries to implement Integrated Solid Waste Management approaches. In Switzerland, levels of law enforcement are high since principles of good governance, democracy, participation, raise environmental awareness and capacity building in environmental issues to ensure compliance with solid waste regulations. These principles are also applicable to the target countries where strict enforcement of the law should be promoted progressively through an effective enforcement programme.

Law enforcement is also linked to the assignment of roles and tasks of solid waste management legislation in the target countries which is usually fragmented, and several laws (e.g., Public Health Act, Local Government Act, or Environmental Protection Act) include clauses on rules and regulations regarding solid waste management. The rules and regulations are enforced by the different agencies. However, there are often duplication of responsibilities of the agencies involved and gaps in the regulatory provisions for the development of effective solid waste management systems

2.3.4 Organisational elements

Switzerland combines private and public funding to meet all organizational elements. Private-Public Partnerships (PPPs) can be enhanced in the target countries by extending the involvement of the private sector in partnership with local African governments. Private sector can set up recycling centres, landfills and incinerators. A clear assignment of responsibilities among national, regional and municipal authorities, private sector organisations and individuals, as well as the control of the public sector have been proven to be key factors of success.

Industrial waste and WEEE are under the responsibility of the respective producers in Switzerland. The organic fraction of theses wastes in most cases is, if it is neither toxic nor hazardous, disposed of in public municipal waste incineration plants. Collection and disposal is financed on a private-sector basis. Retailers, manufacturers and importers are required to take back, at no charge, those types of appliances they sell. Consumers are obliged to return appliances. Inadequate law enforcement is the main constraint to extend this practice in the target countries however partnerships and agreements between private and public sector can enhance the compliance of the polluter pays principle

2.4. Evaluation and adaptation of practices from Netherlands

2.4.1 Logistical elements

2.4.1.1 Waste collection

The waste collection in the Netherlands is practised on a regular basis. For example Rotterdam and other towns undergo frequent collection of waste. Households have the choice between a bigger container and a less frequent collection, and a smaller container with a more frequent collection route. It has to be emphasised that households, institutions and producers practise waste separation in which waste streams are separated into plastic, glass, paper, organic waste and municipal waste (Fransen, van Maaren and Scheinberg, 2010).

The frequent collection of waste is one criterion which can be adapted from the Netherlands. Its advantages are discussed below:

2.4.1.2 Waste separation

The separation of waste is a method to be applied in the target countries. According to Zurbrugg (2003), the component of organic waste is higher in developing countries than in developed countries. Zurbrugg considers the amount of packaging and processed food. Other factors which influence waste composition include availability and economic power of the habitants, climatic conditions in which the tropical climate offers wider food availability over the year which influences the waste composition.

2.4.1.3 Separation of organic waste

In a hot climate, humidity causes a faster degradation of organic substances in municipal waste which leads to release of odour, and attracts flies and vermin if mixed waste is collected and kept for a while.

More than the half of the municipal waste is biodegradable (Medina, 2007) and its separation from municipal waste would make the refuse collection easier. Municipal waste free from organic parts and recyclables weighs less and more waste from the neighbourhood or area can be transported. The municipal waste is less moist and does need little separation and treatment before its final disposal. Organic waste can be treated at home for example in individual home composting activities, in the neighbourhood (urban gardening) or in composting facilities in which commercial compost is being produced and sold. These options require the separation of organic waste at household level: household members ideally have to throw organic waste into compost bins. Certain of these wastes may also be used for feeding animals.

2.4.1.4 Separation of recyclables

The separation of plastics, glass, metal, paper and cardboard practised in the Netherlands can be also applied in the target countries to further reduce the amount of municipal waste from households, institutions, small business operators such as restaurants or shops and from manufacturers.

The collection frequency of municipal waste can be reduced since the organic wastes and recyclables have been removed. In target countries, especially in suburban and rural areas, where asphalt roads are less common or access in towns with collector trucks is difficult or inappropriate, waste separation may help to reduce the volume of waste so that the waste can be transported in smaller vehicles to bigger bins and collection points from which the waste can be collected by trucks and brought to disposal or recycling facilities.

In the Netherlands, waste is being collected in containers which are supplementary to the waste collection trucks. This is hygienic and practical for the workers and householders who handle the waste. The choice of a suitable bin or container must be based upon these considerations, but also will depend on the collection systems (the vehicles used) access, infrastructure and the space required for the bin storage area.

2.4.2 Technological elements

2.4.2.1 Collection and transportation practice

In the Netherlands municipal waste is collected frequently. In Rotterdam, for example, the collection frequency depends on the size of the bins. Households with a bigger container need to be emptied less frequently than smaller bins (Fransen, van Maaren and Scheinberg, 2010). In densely populated areas, such as in urban areas, it is of advantage to introduce mobile compactor trucks to compact the high volumes of waste and transport them the long distances outside of the urban areas to where the recycling, waste treatment or final disposal sites are located. Furthermore, compaction of separated waste can increase the lifespan of the landfills.

2.4.2.2 Recycling and treatment options

In the Netherlands the waste management is linked to the Lansinks Ladder[1]. Recycling is the third step after prevention and design for prevention for beneficial use. The Environmental Management Act requires local authorities to establish systems for separate collection of kitchen and garden waste from households (Senternovem, 2006). Producers and importers are required to take back and reprocess their goods. Product recycling is encouraged for example, introducing refundable deposits. Having a look on the figures for the Netherlands the amount of waste being recycled has increased threefold in the past 30 years. Various recycling options and practices do already exist in the target countries but can be improved. Nevertheless, the Lansinks Ladder is an important approach of consider in the waste hierarchy and all countries are encouraged to take this into account from design to the disposal of the product.

2.4.2.3 Final Disposal

In terms of final disposal in the Netherlands, the aim is to recycle as much as possible due to limited required area for landfill and its high taxes. It is prohibited to use landfills as the only final disposal method. Recycling, mechanical biological treatment and incineration have to be applied before waste enters the landfill (Ministry of Housing, Spatial Planning and the Environment, 2001). This practice has gained importance in developed and crowded areas such as in Europe. In the Netherlands the choices solid waste management systems have been motivated by the fact that taxes for storing waste in landfills were enormously high and recycling options were more profitable (Senternovem, 2011). Incineration plants provide a good but an expensive option for developing countries: a sanitary landfill would provide a much greater improvement than uncontrolled dumping or burning of waste which leads to emissions of toxic substances into the ambient air or leachate from uncontrolled dumpsites. Secondly, in spite of the advantages of incineration (energy recovery, decreased methane emissions and less space for final disposal), the burnt material is lost. In developing countries, where recycling-technology options may not be as sophisticated as in the Netherlands, valuable resources are wasted if it is burned. Nowadays, old landfills are "re-opened" to obtain valuables from the past which are present because separation of wastes was not practised as today.

However, for increasing populations and establishment of mega cities such as Lagos in Nigeria with 12 million habitants, incineration might still be a better option where collection and transport of waste over very long distances to treatment and disposal facilities is required. Urban planners have to consider the availability of suitable areas for landfills and other waste treatment facilities in the future planning for medium sized towns which will grow in future.

2.4.3 Legal and organisational elements

2.4.3.1 Lansinks ladder approach or the waste hierarchy

Remarkable for the Netherlands is the Lansinks ladder approach, which is now part of the EU-Directive (Senternovem, 2011). Its approach in preventing waste in the first place is a very intelligent and necessary step in the waste hierarchy. This approach can be regarded as a necessity in all countries for all levels of waste generation to save resources and energy.

A further consideration to the "cradle to cradle approach (Mc Donough and Braungart, 2002) in which used materials for items can be the inputs into a different process or composted, rather than being discarded.

2.4.3.2 Taxes

Taxes are an important tool in waste management in the Netherlands. Landfill taxes, in addition to the landfill ban, make the other activities such as prevention, segregation and incineration of waste more lucrative.

Secondly taxes in municipal waste for consumers have doubled in the Netherlands since 1990 in order to finance separate collection, recovery and disposal capacity and guarantee environmental protection. The waste producers were also consulted.

[1] The waste policy follows a hierarchy in waste management, which corresponds broadly to 'Lansink's Ladder' (named after the proposer of the motion passed unanimously by the Dutch Lower House in 1979)

Taxes are method to sustain the waste management systems, and have to be considered in the target countries too.

Waste related taxes in the target countries are an option but need to be adapted to the economic power of the consumers. Ideally, consumers and waste producer understand the introduction of taxes otherwise householders and producers may refuse to pay and dispose their garbage inappropriately. Taxes nevertheless have to be used for the waste management system which needs to be controlled and evaluated from time to time. The recognition and acceptance of taxes and collection fees are linked with environmental education and will be discussed in the next section.

2.4.3.3 Environmental education

The prevention of waste generation, separation, recycling and composting activities is an outcome of growing environmental awareness.

Information on the environment and solid waste management were introduced to different segments in the population such as households, institutions (schools, hospitals, universities) in leaflets, a waste calendar, campaigns, and progress reports on the improvement of the environment such as quality of water, air and soil.

Other forms of environmental education have been embedded in curricula. Environmental issues were discussed in sciences in schools, apprenticeships and universities. This education and training not only raise environmental awareness but generate technical personnel who can be employed or operate important sections in the solid waste management sector such as industries and SMEs. This is an important measure to be applied in the target countries too. Methods of creating environmental awareness can vary depending on culture and specific needs.

2.4.3.4 Producer's responsibility

In the Netherlands the National Policy aims to minimize waste and recycle waste as much as possible. The National Waste Management Plan was introduced in 2009 and will run till 2021 (Senternovem, 2011). In this plan producers finance their obligations via advanced disposal fees for e.g. batteries, white and brown goods, automobiles or they pay directly for its disposal as for waste electrical and electronic equipment, paper and packaging. This is an interesting and effective approach and can be applied in the target countries too. Manufacturing companies and industries can be regarded as the producers generating waste during the production of goods and resources. However, a wide range of products that result in waste not suitable for recycling originate from imports. These might include donated goods or e-waste that are imported to recycle usable parts under cheap conditions in the absence of strict regulations but which negatively affect human health and the environment. In this context good governance plays an important role (e.g. control in import of goods and application of laws) to protect the health of a country's people, environment and economy.

2.5. Evaluation and adaptation of practices from Spain

2.5.1 Logistical elements

Collection systems for solid waste established in Spain and France, are mainly focused on post-consumer and post-industrial waste. The most common method for waste collection is via drop-off containers which can be distributed in different zones of the municipalities, installed in the stores where the end-of-life waste (e.g. WEEE, end-of-life tyres) is replaced when a new product is bought, or located at specific collection points (transfer stations).

In the target African countries, the low containerisation rates do not make it suitable to establish SWM models from Spain and France. Moreover, high tech collection vehicles for such a sophisticated selective collection system (household packaging, agrochemical packaging, medicinal packaging, WEEE, batteries and accumulators, cellular telephones, lighting systems, end-of-life tyres etc.) cannot be expected for Nigeria, Ghana, Ivory Coast and Senegal. Therefore, the encouragement of the citizen and industries by establishing a necessary number of collection points would be the most suitable solution. Collection points would be meeting points between

citizen and informal waste pickers (they would pick solid wastes up from homes stores, hotels, restaurants or municipal dumps, to the collection points) and the reuse or recycling industries. Valuable solid wastes regulated markets could be created at waste collection points so they would function as solid waste transfer stations.

Hazardous waste collection should be strongly promoted in the four African target countries. In Spain some hazardous waste collection systems are established such as agrochemical packaging (collection by depositing packaging at specific collection centres) or batteries and accumulators (collection in containers distributed in municipalities, stores etc for household and professional wastes). These hazardous waste management systems could be adapted in Nigeria, Ghana, Ivory Coast and Senegal. Hazardous solid wastes should then be transported to specific treatment industries.

2.5.2 Technological elements

Spanish and French SWM systems use high tech collection and treatment technologies like, sophisticated collection vehicles and containers, underground transportation of organic waste by pneumatic systems, a high rate of containerization, recycling and waste to energy processes, most of which are not suitable for target African countries. Simple waste collection equipment like waste cans or bins distributed among citizens would be more useful and suitable for depositing waste at collection or transfer points.

2.5.2.1 Recycling

The recycling industry in Spain and France is fully established with very advanced technology and facilities. Final treatment is guaranteed for all the wastes collected by the established SWM system in both European countries.

Regarding target African countries, the existing few recycling facilities should be encouraged and technologically improved as much as possible. Moreover, existing low tech sorting and recycling technology should be promoted as appropriate for establishing new recycling plants.

Treatment of hazardous solid waste usually means advanced technologies. However, there are some suitable and simple hazardous waste methods of rendering hazardous wastes inert such as the encapsulation of waste in concrete or the addition of lime, which could be a step before landfilling.

2.5.2.2 Final Disposal

Landfill is the most common final disposal option in the target African countries even they can complemented with recycling practices in order to reduce the environmental impact as much as possible.

When solid waste materials are disposed of in a landfill they can remain unaltered after decades. It is worth mentioning that the most of solid wastes are not a bio-degradable, hence they are a source of soil contamination and in the long term the cause of severe environmental impacts such as degradation of soil fertility, and pollution of surface and subsoil water. Besides the above impacts, the embodied energy present in the wastes is lost.

The waste-to-energy option could be suitable for non hazardous mixed wastes in the target countries, using the waste as a secondary fuel for industries like cement kilns.

2.5.3 Legal elements

All Spanish and French SWM systems have a total legal support which is essential for their success. In order to have successful and sustainable waste management systems, all the target African countries have to ensure is that existing national and local waste management laws, rules or plans are fully implemented and financed. Solid waste management can also be indirectly included as part of policies addressing broader issues such as various economic sectors, like industries, agriculture, healthcare facilities, construction and demolition activities, etc.

With an aim to improve and adapt solid waste management systems, target African countries should develop the necessary regulations in order to cover principal waste management system

key points as "classification, collection, temporary storage, transportation, treatment of wastes"; "regulation and procedures on disposal and landfill of waste from private or industrial sector", "requirements on waste containers and waste collection points" and "regulation on hazardous waste".

2.5.4 Organisational elements

In Spain and France, as in many other European countries, solid waste management systems are managed by a private, non-profit company or an association which permanently collaborates with political authorities and private company associations. In the African target countries, the management system must implement this collaboration model between SWM managers and authorities (industrial and municipal) which also involves all the stakeholders.

However, most municipal authorities in target African countries are providing SWM services very inefficiently or are not providing any SWM service at all. Old and inappropriate vehicles and tools for collection, inadequate transport, and inefficient disposal not only cause unhygienic working conditions and slow down the process but also severely affect the environment. Productivity is very low, resulting in a high unit cost of service. Collection coverage rates are not high. The collected waste is disposed of at open dumps within or outside cities, causing health hazards and environmental degradation.

This unsatisfactory situation makes it necessary for the municipal authorities to seriously consider new concepts and approaches for improving services. Private sector participation is an interesting option for boosting performance, whereby the municipal authorities change their role from service provider to regulator and service facilitator. Different forms of collaboration with the private sector can be envisaged, involving different types of agreements and preconditions of partnership.

Enabling improvements through the participation of the private sector depends on the political will for change; clear agreements and contracts; the public authority's ability to regulate the service, monitor performance, and enforce the terms of agreement; financial capacities; and mutual trust between all partners.

3. EVALUATION AND ADAPTATION OF PRACTICES IN AFRICA – EXAMPLES FOR SUCCESSFUL ISWM SYSTEMS

3.1. Evaluation and adaptation of practices from Egypt (further Arabian states in Africa)

In all target countries there is a need for a balance between meeting urgent needs and planning for long-term best practices, and therefore all case studies previously discussed in the report can be used for reference and are evaluated below.

3.1.1 Successful technologies

There are successful technologies which offer several lessons-learnt for the target countries, Ivory Coast, Nigeria, Senegal and Ghana as follows:

3.1.1.1 Landfill

Landfills in Egypt were a successful example in providing safe and timely means of disposing the wastes of dense cities. In El Hammam landfill in Alexandria, approximately 13 million tonnes of waste will be deposited in the two landfills over the 15-year contract term with the private company Onyx. It is currently in satisfactory operation. The technology involves landfill gas (LFG) capture and utilization as an energy source to evaporate the leachate collected or otherwise it is flared.

Leachate collection is particularly important in countries in West Africa where the ground water table is high and precipitation is high compared to the case studies presented in Egypt. This is particularly important in a case such as of the old landfill of Atiekoi in Abedjan, Cotê d'Ivoire that is currently being considered for upgrading or replacement since it is situated directly above groundwater reserves. El Hammam landfill in Alexandria also includes permanent groundwater monitoring wells.

3.1.1.2 LFG Recovery for Carbon Credits

The Onyx project qualified as a CDM and generates additional revenue from carbon credits. In the more rainy West African countries there is likely to even be a greater benefit from CDM projects since the baseline emissions of methane (the business-as-usual scenario) are likely to be higher, which means more potential for carbon reduction. This is due to the fact that wet conditions from rain or high water tables are more likely to provide anaerobic conditions in the dumped waste heaps or waste pits, which in turn causes greater methane emissions. Such conditions make the waste management projects even more lucrative in terms of generating carbon-reduction revenue.

Although this is a valid option, decision makers should be inclined to establish a system where organic waste is recycled through composting. The time required for establishing such a system would vary from region to the other however, and interim solutions might be needed, such as allowing organic waste to be landfilled during this transition period.

3.1.1.3 Hazardous Wastes

Nasria Hazardous Waste Management Project in Alexandria is a successful example of how to start in phases toward better hazardous waste management. West African nations are in a similar early phase of developing this subsector and can therefore benefit from this experience. Phase I of the facility included a secure landfill and solar evaporation ponds to receive wastes, and Phase II includes mechanical and chemical treatment, solidification, and interim storage. Solar evaporation ponds in rainy areas however would be replaced with other evaporation systems, which might imply higher costs unless the cost savings from less land-area needs would compensate.

The Nasria project proved to be a stimulator for further developments in this field. The facilities are yet to expand to incorporate more hazardous waste treatment, such as in the current plans for Compact Fluorescent Light bulbs (CFL) recycling in cooperation with the Korean International Cooperation Agency (KOICA).

3.1.1.4 Informal Sector know-how

Egypt has gone a long way towards incorporating the informal sector into its SWM systems and in recognizing its technological capabilities and inherited know-how. This has happened not only through successes such as in the case study of the Association for the Protection of the Environment (A.P.E), but also in many failures that caused uprisings from local communities that were affected by sweeping privatization measures over the years. APE was successful in empowering the informal sector to professionalize recycling activities and improve their practices, and is therefore a valuable reference for regions in transition toward formalizing the sector. The APE activities in the Garbage City in Cairo show how such an intervention can convert a problem into an opportunity for community development, women empowerment and job creation, while building on the local cheap technology.

Regarding health and safety, similar recycling technologies may be found in West Africa, but interventions to ensure health and safety are necessary. The case of APE shows that technology needs are diverse, whether to produce carpets, table mats, hand bags, postal cards, envelopes, page markers and various other items that might require heavy machinery such as plastic granulators, plastic injection moulding machines, film making machines, extruders and many other specialized equipment. However, it is important to ensure education on health and safety is provided in any development intervention such as conducted in the APE project in Egypt. This must be taken into account in discussions of technologies with the informal sector. It is also necessary to recognize the significant contribution of the informal sector and its technologies in solving the immediate waste problems.

Regarding e-waste, the MANAGEM and Al-Jisr GREEN CHIP Project in Morocco is a flagship project in the region demonstrating how part of the recycling involving dismantling can be carried out using simple tools and technologies that open up job creation and learning opportunities, while the expensive technology needs for further processing are available at the heavy industries. This is relevant to countries in West Africa where it is possible to identify established industries that can benefit from extracting precious and nonferrous metals from e-waste.

3.1.2 Best organizational practices

The following organizational practices are success stories that should be used as references for West African Nations, but should, however, be applied only where similar conditions are identified.

3.1.1.5 Local Management through Hemaya CBO in Sinai

The model of Hemaya NGO in Nuweiba in Sinai, Egypt, demonstrated how local management can be an effective alternative to the costly foreign companies that might be monopolizing waste management with comparatively poorer performance. This is relevant to certain parts in West Africa, or in any country with similar local conditions, i.e. rural areas and small urban communities, or indigenous communities located in tourist areas, in addition to the most important element, the will of the local community to develop their SWM system and to partner with other experienced organizations and stakeholders. The formation of an NGO was a simple way to institutionalize the community's initiative, qualify them to receive financial support to build a regional waste transfer station and enable them to sign contracts with local hotels and the City Council to collect and sort waste.

3.1.1.6 Advent of Private Sector ONYX in Alexandria

In Egypt, the process of privatization has slowly matured after several failures. Today, governorates are vested with the authority to negotiate and contract waste management services with private operators as a common practice. They are authorized to collect a fee-for-service to support them in meeting their contractual obligations toward the private operator. The experience with the first international company to penetrate the market in Egypt, ONYX Company, is still operating successfully to date. With time however, more consideration and acknowledgement of the informal sector has slowly moved towards creating a reasonable balance between the interests of the various stakeholders and vulnerable communities who were previously dependent on the informal waste industry. This is one of the key challenges to the success of any private sector operation and the cause of many private sector failures in Greater Cairo region.

It is important, however, to invest sufficient time and resources in drafting a good contract and to monitor contractual obligations. For example, in Egypt, a Contract Monitoring Unit was established to oversee the implementation of the agreed work plan. Previously, many failures of other companies occurred and they could not be held accountable due to poor drafting of contracts and poor monitoring.

3.1.1.7 ANGED Project in Tunis

Tunis hosts an organization that is solely dedicated to solid waste management, which has saved significant time in developing the sector without the stumbling blocks that were faced in Egypt. The organization is National Agency for Waste Management (ANGED), known in Tunis as Agence National des Dechets, established in 2005 under the Ministry of Environment and Sustainable Development. It is responsible for planning and implementing policies, plans and projects. The success of this approach, which recognizes the unique scope of SWM systems and their challenges and further raised the status of SWM, is an example of good practice for nations in earlier stages of SWM development.

3.2. Evaluation and adaptation of practices from South Africa

3.2.1 Successful technologies

This chapter discusses technologies that have been shown to work successfully in waste recovery and treatment programmes (both on private and public sector level) in the specific Southern African context. A strong word of warning is issued that any developing African country should not simply try to copy technically sophisticated (and often most costly) European or US type solutions but has instead to ensure that any waste management technologies considered are suitable for the particular existing socio-economic profile of the population (e.g. meaning they reflect the waste mix and volumes as a direct reflection of their disposable income) and consider infrastructural framework conditions and limitations given in that country. A case in point is the example of the

City of Cape Town that employed American consultants in the late nineties to conduct an evaluation of Integrated Waste Management Technology options that resulted in one of the recommendations being to procure a wire baling machine for residual waste from a transfer station going to landfill. This recommendation was based on a typical US waste mix that contains a much higher content of "dry" packaging materials than typically found in South Africa where organics "wet waste" (which is much heavier) form the largest fraction in municipal solid waste. As a result, and due to the failure to conduct a proper local waste characterisation study, a technology was procured by the municipality that did not work sufficiently (baled waste blocks regularly broke due to the heavy organic fraction) and had eventually to be replaced.

The following key factors should be considered and carefully evaluated if a decision is made to employ any type of technology to aid waste recovery at source and subsequent better management and minimisation of waste going to landfill:

- **Does the country have a clear legal mandate and political will to "minimise" waste?** (Including the promotion of reuse and recycling). A matter of fact that is demonstrated in the City of Cape Town's recent Municipal Systems Act reassessment which includes a full economic evaluation of the cost of alternative service mechanisms (see also Deliverable 3.1 Section 2.2), the landfilling of waste remains in the short term (and by excluding social and environmental benefits) by far the cheapest and most convenient option. Hence municipalities that depend heavily on cost recovery from its citizens for disposal services are likely to pay lip service to any serious waste minimisation attempts unless it is made a clear legal requirement and incorporated as a core business activity in the job description of senior waste managers.
- **Do the technology/suggested project focus correspond to the main problem at hand? Does it satisfy the requirements of both the local waste mix and the waste volumes that are expected to be treated and does it capture and weigh up correctly the key waste generation sources and their related impact?** Generating just above three million tons of waste annually (2008/2009) Cape Town has an estimated 27% overall recovery rate of recyclables (including chipping of greens and crushing of builders rubble, composting and sludge processing) combined from both private and municipal waste minimisation initiatives[2]. The private sector that is responsible for 18% of this overall total recovery rate of 27% while the Municipality contributes much less. Unbundling what is recovered it was shown that while the recovery of recyclables from industrial sources constituted (weight-based) 6.5% out of the total of 27%, the recovery of recyclables from households does not exceed a measly 0.4 %. Builders rubble re-use by crushing however weighs in with an almost 12% recovery while sludge pelletisation and alternative usage yields nearly 4% waste reduction to landfill. Before the focus can be placed on any particular waste minimisation initiative or technology it is important to evaluate the relative impact of particular waste streams and waste sources on the type of waste crisis practically at hand.
- **Does the technology reflect the resources at hand?** It makes no sense to opt for a very costly, low labour oriented, highly technical solution that depends from the outset on external operation expertise, a high level maintenance service based outside of the country and spare parts that need to be imported. Even more so if the proposed technology is located in an area with high un-employment rates, an abundance of unskilled labour happy to work for a low wage and where crime and (metal) theft is a common problem. Many examples exist in Africa where multi-million dollar investments for waste and waste water treatment plants have become "white elephants" after only a few weeks in operation because criminals systematically dismantled units for the mere benefit of recovering "scrap metal value" and the upkeep of such plants by re-ordering the stolen parts proved too costly for the operator
- **Does the "turnkey" waste management technology solution offer a care-free finance plan and are certain attractive "purchase perks" attached**? Utmost caution is advisable when flamboyant overseas salesmen knock on the door of cash-strapped municipalities,

[2] Statistics taken from the Akhile Consortium "Draft Status Quo Report (MSA Section 78 (3) to Assess Alternative Service Delivery Options"; November 2010

sometimes with a direct political motivation and very often with hidden political support or vested interest. It is advisable to seek assistance from an independent evaluation body such as the Municipal Infrastructural Investment Unit (MIIU) or the Development Bank of Southern Africa (DBSA) to establish proof of both a sound financial and technical track record of a company. The City of Cape Town's Solid Waste Department has had great success with consulting experts in the field and expensive investment mistakes have therefore been avoided.

- **Is this a proven technology and do successfully operating pilot plants exist elsewhere, ideally somewhere in Africa?** Sadly African countries remain the target of unscrupulous companies that often sell technologies that are either outdated overseas or that are not up-scaleable from a much smaller and more controllable pilot plant.
- **Does the technology match the task at hand?** Many waste to energy technologies focussing on multiple stage incineration, pyrolysis and even plasma arc technology (used for the destruction of ammunition and chemical weapons in the US) have been boldly presented to South African municipalities as a solution for municipal solid waste treatment. More often than not such high-tech overseas technologies are ill-suited for African-based Municipal Solid Waste treatment. In countries with much less plastic and paper packaging waste in the waste mix than in Europe and the US, the calorific value will be considerably lower resulting in compromised heat/energy generation from the outset.
- **Does the suggested technology benefit the local community at large in any way –either directly or indirectly?** Like any other management decision a triple bottom-line evaluation (economic, social and environmental) should be conducted prior to implementing any new technology in order to ensure that sustainability principles are adhered to at all times. All too often waste sorting or recycling technologies are chosen that bear a high initial financial outlay as well as massive ongoing operational and maintenance costs for high-tech equipment. Such technologies directly jeopardize the opportunity for much needed job creation in the low and unskilled sector. When it comes to environmental considerations, African countries are often regarded as "pollution sinks" in the global landscape. As it was once so aptly expressed by a US consultant to the author: the entire African continent is perceived to be still "severely under-polluted". This mindset needs to be kept in mind particularly, every time countries are encouraged to build special waste treatment facilities in lieu of monetary loans to enable the reception of foreign waste materials, or when governments are offered waste treatment related Cap and Trade models to offset carbon emissions overseas (http://www.storyofstuff.com/capandtrade/). The large scale dumping of toxic industrial waste generated in overseas countries along vast stretches of the West African coastline is already a reality that needs to be urgently addressed. To this end the Basel Convention restricting trans-boundary movements of hazardous waste needs to be enforced strongly by all African countries.

3.2.1.1 Evaluation of Recovery and Recycling Technologies that work well in South Africa

Post-Industrial Waste

By definition "post industrial" waste (also termed "pre-consumer" waste) are materials that are generated as "waste" in the manufacturing process of consumer goods across a wide range of various economic sectors. It is estimated that for 1 ton of waste generated at household level the industry generates an equivalent of about 70 tons of waste to make those products from resources (99% of which in the US alone becomes waste within the first six months[3]). Hence following the 80/20 principle which seeks to minimise efforts while maximising outcomes, the potential and ease of recovering post industrial waste is enormous if compared to the challenge of source recovery of household based (post consumer) waste materials. Post industrial waste materials have the advantage that they are typically generated in large and consistent volumes and fairly clean if a

[3] www.storyofstuff.com

basic source separation from any wet wastes is followed at its point of generation (being typically on manufacturer, assembly, supply or trading level). Targeting only the top 10 municipal, regional or national post industrial waste generators with any waste minimisation programme will most likely have a much stronger impact than trying to tie up millions of households in a pre-consumer type separation, collection and recycling initiative.

The private waste management and recycling sector is well aware of the "low-hanging fruits" their industrial/commercial clients provide with regard to the recovery of valuable waste resources such as packaging waste materials, scrap metal, plastic and textile off-cuts . Hence in South Africa there is readily developed infrastructure which has been growing rapidly in the last five-ten years in direct response to the available material sources. Most private waste companies now actively encourage and educate their clients to practice source separation and some even offer financial incentives to do so e.g. by offering a "pay as you throw" contract instead of setting a flat monthly removal fee. Most of the large waste companies operating in South Africa have developed state of the art Material Recovery Facilities (MRF) that provide source separation with the aid of some basic mechanical and physical principles (e.g. magnets to recover steel) but otherwise rely heavily on manual sorting. The capacity of a privately run MRF in Cape Town is around 1,200 tons/day which gives an indication how much materials are recovered for recycling coming straight from the offices and factories of product manufacturers. The private waste sector contributes 18% recovery for recycling which is by far the largest part of that.

When it comes to post-industrial recycling it has been shown that the market very much regulates itself and recyclers readily accept such materials due to their relatively high value and ease and reliability of access. In particular certain plastic recyclers only accept waste material from post-industrial sources and will not touch post-consumer waste due to its high contamination potential. In conclusion Governments should place much more emphasis on supporting post-industrial recycling e.g. by giving subsidies or tax breaks to promote the setting up of recycling plants as an integral part in the development of a national/regional/local sustainable recycling economy.

Post-Consumer Waste

Post consumer waste is by definition any municipal solid waste that is generated at household level. In South Africa the quantities generated within each household unit most often show a direct correlation between the size of the household and it's the disposable income. These quantities lie around 0.9 -1 kg per household per day. As a rule of thumb typical dry recyclables such as packaging waste are prevalent in the waste mix of medium to high income households while low and no income areas (including the informal sector) contain very little of such materials. Whatever is bought as packaging and results in "waste" is brought to a buy-back centre[4] to recover cash rather than given to a voluntary municipal recycling programme such as "Think Twice". To this end the City of Cape Town has embarked on a household recycling separation programme under the name of Think Twice that captures about 10% of all formal households (mostly medium to high income) in Cape Town. As described in more detail under an earlier deliverable under this project, report Deliverable 3.1, Section 2.2.2.2 the operational costs for the current recovery footprint and modus operandi are very high for the City which has outsourced the participating areas to three private waste companies. Transport costs are increasingly prohibitive considering that only an average of about 2-4 kg of mixed recyclables per week are recovered from a participating household. This represents a contribution to Cape Town's overall recovery rate of 27% (public and private sector initiatives combined) as mentioned above of not even 0.5% in total. For the City of Cape Town the recovery from selected suitable households comes with a hefty price tag of about $ 200/ton recovered which is the reason why the City is hesitant to roll the project out any further. The methodology of the Think Twice campaign is very simple and straight forward. Participants are encouraged to collect all their dry recyclables in a clear bag which is provided by the appointed service provider on the day of collection. Householdes are asked to place the recycling bag on top

[4].Buy-back centres in Cape Town are also exclusively private sector initiatives. There are approximately 26 buy-back centres operating within the City next to 22 municipal run drop off sites.

of their other waste in the 240 l wheelie bin and on the day of normal waste collection recycling trucks (high-walled open trailer units and definitely no compaction vehicles[5]) go around prior to the normal municipal collection round to pick up bags. Some areas have participation rates as high as 80% however informal collectors and vagrants have posed a threat in some areas where bags are pillaged prior to collections being done by the City of Cape Town's officially appointed Think Twice service providers. To this end some service providers have chosen to formalise business relationships with informal collectors by offering them the buy-back of the bags they retrieve at a set price and at a convenient location close to the Think Twice pilot area. Letting the existing informal sector participate instead of fighting them by trying to displace them translates to less collection work and decreased house-to-house transport costs for the appointed collectors. Participating informal trolley collectors are easily recognized by wearing a vest including their picture on an "ID" card which provides them with a sense of value and importance while giving the householders "peace of mind" if bags are removed by recognisable individuals.

The basic principle for any successful post consumer waste collection is to reduce the logistics cost by treating on site (e.g. promote home composting and home-based worm farming to reduce waste organics) or as close to source as possible, or by providing drop off facilities within a reasonable distance from households. However for a metropolitan like Cape Town this still means up to seven km from any given household to the nearest drop-off site which makes it inconvenient and inefficient for some householders to go there. Drop off sites are also costly and labour intensive for the City to operate and this is where the private sector should come in as an enabler for public take-back infrastructure.

The emerging role of retailers to fulfil the take-back obligation

The South African retail industry has been clearly ear-marked by National Government to become a key role-player for a future nation-wide post-consumer waste take-back system and as part of the country's attempt to achieve waste minimisation and to maximise waste beneficiation initiatives by enforcing the "extended producer responsibility" principle. In recent years numerous voluntary private sector retail initiatives sprung up nationwide including wholesale electronic goods retailers such as Macro who put up designated containers for e-waste in their parking lots to enable take-back of e-wastes. Food retailers such as Pick'n Pay and Woolworths have also started to test the set-up of take back points (including forging partnerships with selected petrol stations such as Engen and BP) for the take-back of household-based items ranging from plastic bags, glass and waste paper to more exotic but environmentally challenging waste items such as print cartridges, CFL lamps and batteries. Since retailers are at the heart of trading goods that subsequently produce post-consumer waste it makes good sense to assign them the role of the ultimate convenient take-back option for shoppers – similar to their counterparts in Europe. Municipalities should expect the private sector to make both logistical and financial contributions towards solving a waste problem that originates from them in the first place.

In areas where there are no Think Twice activities in place but where people wish to be included in a recycling drive, some private entrepreneurs such as "Abundance Recycling" have emerged who offer the collection of household recyclables from voluntarily participating households on a weekly basis for the equivalent of about $ 10 per month. With escalating transport costs (due to almost monthly increases in the fuel price) and raising disposal costs for the non-recyclables received it becomes however increasingly difficult to keep such private initiatives viable.

As with the pre-consumer waste, post collection waste material sorting takes place in either private or municipal Material Recovery Facilities. Typically 90-95% of what is found in a "mixed recyclable" bag finds its way to the respective recycler. This picture changes however dramatically if an attempt is made to recover contaminated recyclables from a mixed municipal solid waste stream that has not been segregated in any way. Numerous pilot projects have proven the high rate of failure if recyclables are not recovered at household level but only further downstream. Due to the

[5] Pilot studies of placing recyclables in thicker (40 µm) bags so they can be co-disposed and collected in a compacting vehicle with other waste (e.g. organics) and then recovered at the landfill site proved to be unsuccessful as bags broke due to compaction plus they also tore further in any attempt to pull them out from other waste at the landfill site.

high contamination of materials from organic waste, typical recovery rates in a "dirty" MRF are not much higher than 5%, rendering such an approach non-viable from the outset.

Municipal structures in place to support waste minimisation of both post industrial and post consumer waste:

From studies conducted as part of the City of Cape Town's Waste Status Quo report informing the MSA Re-Assessment Study (see also below) major fractions that currently end up on local landfill sites are organics (greens, organic trade waste and household food waste), builders' rubble and packaging waste.

To this end the City of Cape Town has started to retrofit (where possible) existing municipal drop-off sites with chipping facilities to feed existing downstream composting businesses.

Builders' rubble is still a huge issue since crushing of rubble is offered only by private services. Most of the rubble ending up on landfills is used to stabilise slopes. The problem is that with the larger Cape Town metropolis now rapidly running out of landfill space, a decision was made in 2010 to charge for the commercial reception of builders rubble (about $ 80 per bakkie truck) to preserve remaining landfill space. This has led to a massive increase of illegal dumping all over the Cape Peninsula, as small scale entrepreneurial rubble removers are clearly not able and/or willing to absorb such additional costs. From a planning perspective the problem is that the original generator of the rubble (i.e. the re-developer or renovator) should be made accountable for financing its disposal, or more ideally, it's crushing and re-working. This requirement should form part of the renovation/building planning approval process. The City is currently trying to establish a work group with key stakeholders in the building and rubble removal industry to find a viable solution.

The packaging waste found on landfills forms part of unsorted trade and household waste and pickers normally do not manage to recover more than 1-2% of such materials at a landfill. This emphasises the need to focus on source recovery of recyclables predominantly in the industrial, business and trade sectors where the largest volumes are typically produced, and to a lesser degree at private households. This is where it is most expensive and difficult to achieve meaningful recovery volumes to justify costs for collection and transportation. Picking scraps from a landfill site (as a direct result of failed up-stream material recovery intervention) is neither dignified or safe nor is it effective in any way and should therefore not be considered to be an acceptable "solution" as part of a well thought out and executed municipal Integrated Waste Management Plan. A waste type and waste source analysis of a landfill can go a long way to first identifying and then addressing waste issues where they really need to be addressed - i.e. at source

Sewage Sludge

40% of the daily sewage sludge production in Cape Town already has a solution that does not include landfilling: it is pelletised and sold to a willing buyer and a receptive market. However the remaining 60% or 525 tonnes per day require a different solution and present energy to waste opportunity together with the organic waste fraction within the municipal waste stream. This could take the form of anaerobic digestion to create bio-energy. Technical options are currently being explored by the City of Cape Town.

3.2.2 Best organizational practices

3.2.2.1 National Environmental Management: Waste Act and Waste Management Strategy

3.2.2.2 The Institute of Waste Management of Southern Africa: IWMSA

Professionals in the Waste Management sector in South Africa are widely represented by the Institute of Waste Management of Southern Africa (IWMSA) which also has loosely associated chambers in its neighbouring countries Botswana, Zambia and Zimbabwe.

IWMSA is a multi-disciplinary non-profit association that is committed to supporting professional waste management practices along the entire waste management hierarchy ranging from waste prevention and minimisation at source right down to responsible landfilling and alternative waste to energy solutions. Members within IWMSA promote environmentally acceptable, cost effective and

appropriate waste management practices suitable specifically for the Southern African context where poor waste management practices are unfortunately still found (in particular in rural, low skilled and cash-strapped municipalities).

IWMSA serves as a clearing house for any waste management related information and actively works towards the improvement of waste management standards and legislation. IWMSA also researches international, national and regional trends in best environmental practices and promotes the science and technology of waste management. To this end education and training programmes have been developed and are held throughout South Africa to introduce municipal waste managers and other interested parties to best practices in integrated waste management. To date none of the training programmes are officially accredited by the South African Sector Education and Training Authority (SETA) which is an issue IWMSA is currently trying to resolve by training selected IWMSA members as SETA accredited course assessors and facilitators. Offering SETA accredited course material and trainers offers the advantage that IWMSA could tap into skills levies that need to be paid by employers within each economic sector, in terms of the Skills Development Levies Act and would therefore obtain access to funding for waste management education and training.

3.2.2.3 Interest Groups and other Communication and Learning Platforms of IWMSA

IWMSA has branches in Gauteng Province, KwaZulu Natal, Eastern Cape and the Western Cape and is hence successfully represented throughout the main economic activity areas in South Africa. Each branch is organized in specific Interest Groups namely a

- Collection and Transport Interest Group
- Landfill Interest Group (LIG)
- Waste Minimisation and Recycling Interest Group (WMRIG)

Recently a motivation was put forward by the Western Cape Branch to add a fourth interest group named: "Alternate Waste Technologies Interest Group". Its proposed focus will be the exploration of new technologies around mechanical, biological and waste to energy waste management processes.

The Interest Groups prove to be a very powerful instrument to ensure the focus is kept on the key deliverables and objectives IWMSA subscribes to. Regular outings and workshops are offered within each interest group, which ensures continuous learning and networking between the members. Other powerful communication platforms include the IWMSA website (www.iwmsa.co.za) and the "Resource" magazine- a monthly publication that gives feedback on specific waste topics, key private sector and municipal waste management projects including new technologies applied successfully specifically in the Southern African context but also beyond those borders.

3.2.2.4 Applying systems thinking in the development of an Integrated Waste Management Plan (IWMP)

In order to fully understand the complexity of designing and operation a truly "integrated waste management plan" for a municipality, region or country it is very important to capture all factors and stakeholders that influence and depend upon an IWMP. Hence officials need to clearly identify the root causes of existing waste management problems before any attempt is made to generate practical solutions that would lead to recommending certain technologies. The system should capture and rate issues according to the Pareto (80/20) principle which will highlight the initiatives that will give the greatest effect with regard to improved waste management (and in particular for any waste minimisation intervention) in the shortest practical time.

The following questions need to be addressed and answered from the outset in developing an IWMP:

- What are the key drivers, inputs, processes, outputs?
- What are the constraints (limits imposed on any solution)?
- What are the financial, environmental and social aspects and impacts/ benefits?

The City of Cape Town recently finalised the re-assessment of its Municipal Systems Act Section 78(3) which included a comprehensive review including research on existing waste types, waste generation rates, waste management practices, CAPEX and OPEX expenditure linked to municipal waste management, recovery for recycling and alternative waste beneficiation rates as well as costs and triple bottom-line benefits for the latter. The aim of the assessment was to identify alternative service delivery mechanisms for solid waste management that are geared towards waste minimisation at source and hence less waste to landfill. The key strategy was first to identify and then integrate municipal and private sector waste management activities that form part of the same system and then optimize the system to achieve triple bottom-line sustainability.

Crucial components of the entire macroscopic system analysis of Cape Town were:

- A comprehensive review of the existing municipal systems for both liquid and solid waste and identification of line functions and related core activities: solid waste management (cleaning, cleansing, collection, disposal services); waste water (effluent/ leachate management); procurement; administration; institutional arrangements.
- Identification and quantification of existing municipal waste management systems, structures and activities.
- Identification and quantification of existing private sector waste management systems, structures and activities.
- Identification of existing wholesale and retail systems with a view to systematically developing and growing them into central public "take back" infrastructural points for the reception of both pre-consumer and post-consumer packaging waste. Retailers must be seen as key stakeholder in the value chain of packaging supplies and are therefore an important partner in enforcing the Extended Producer Responsibility principle in the packaging industry. This is one of the provisions of the National Environmental Management Waste Act, 2008, which the Minister of Environmental Affairs may enforce (although to date the Minister has not yet required this of any industry).
- Identification of private and public logistic and transport systems: road, rail and storage to devise strategies for low-cost, high volume transport of waste materials and recyclables to central treatment and disposal facilities.
- Environmental research that identifies natural resources and ecological systems that should be protected as part of an integrated waste management plan
- Human resources and skills available as part of a demographic, socio-cultural and socio-economic overview. These facilitate adequate planning for population growth and the identification of urban economic growth opportunities to increase prevalent wealth & revenue levels available to waste management – wealth is currently a primary driver for waste service provision and efficiency
- Institutional systems both in the private as well as public sector.
- Lobbying of key stakeholders informing the IWMP such as members of the private sector waste management industry, waste experts, key waste generators, not-for-profit/ NGO/ CBOs etc.[6]
- Review of both the current political and legal system in place on each government level to assess possible risks and opportunities pertaining to a functioning IWMP.

The ultimate challenge in devising an IWMP that serves its purpose for the future challenges of municipal service delivery is to adapt the traditional municipal waste management system comprising cleaning, waste collection and landfilling activities and services, to become an integrated system of partnerships that include waste recovery, processing, climate mitigation and

[6] The City of Cape Town captured over 3000 individuals and organisations on a database that formed the basis of all stakeholder engagement activities in the process including public participation and information workshops as well public opinion gathering via a specially set up website – see also http://www.capetown.gov.za/en/solidwaste/Pages/Section78(3).aspx

recycling initiatives, while providing affordable basic services and reducing impacts on people, the economy, resources and the environment. The role of government itself needs to undergo a dramatic shift from "end of pipe" waste management services towards pro-active "agent of change" motivator and enabler of private public partnerships that can exploit the full potential of both waste minimisation and waste beneficiation.

3.3. Evaluation and adaptation of examples from Ghana

3.3.1 Successful technologies

Waste management in Ghana has seen recent significant changes which have led to improvement in the collection and disposal of waste. The most impressive changes have been witnessed in urban and semi-urban areas where no centralised waste collection and disposal formerly took place. In looking at successful technologies and adaptations in Ghana, the whole spectrum of waste management from collection through to recycling and disposal will be covered.

3.3.1.1 Waste collection

Urban areas in Ghana like Accra and Kumasi have been zoned into first, second and third class areas. The zoning is based on the level of infrastructure in the area. Technologies for waste collection differ significantly in these areas. The use of compactors is predominant in first and second class areas. This is perhaps due to the nature of waste collection which is mostly house-to-house.

In the third class residential areas, because the collection system is mostly communal, skip trucks are used. Residents have a central place for dumping their waste which is then transported to approve dumping grounds by waste management firms. This has been very successful in that these communities already had their own unofficial dumping ground before the advent of waste management services. Residents commute to dump their waste at these chosen places daily. Instead of creating a dumping ground, skip containers are placed either at the old dumping ground or at vantage points within the community that are easily accessible to residents. Skip containers are chosen for third class residential areas because these areas have very poor or non-existent road networks making it very difficult for waste management firms to reach individual households. Also, residents in these areas are relatively poorer and may not be able to afford the monthly charges associated with house-to-house collection of their waste. In some regard, the luxury of placing your waste bin in front of your house for collection daily or weekly is sacrificed for affordability where residents pay a token as they dump their waste. Alternatively, using one-person community contractors offering a door to door service is not necessarily a more expensive option

In rural areas no waste management services exist apparently because of the small amount of waste generated by these individual communities and also the fact that they have developed their own system for handling their waste. For instance, most organic wastes are used to feed their livestock. Other wastes like paper, plastics and metals are thrown into hand dug pits for each household. From time to time residents carry out open burning to reduce the waste volume. When finally the pit is full, it is sealed with sand and another is dug. More recently Zoomlion has introduced tricycles which can be used to collect waste in areas without roads. Because of the manoeuvrability of these tricycles even in bad or nonexistent road networks, individual households can be reached and provided with house-to-house collection of their waste at a very affordable rate.

3.3.1.2 Recycling and treatment of plastics

A number of efforts have been made in Ghana to treat or recycle waste collected in one way or another. Not many of these have been successful, e.g. the centralised Teshie Nungua composting plant. In spite of these failures, some private individuals have very successfully taken on their own initiatives: one such company is Trashy Bags where plastic waste is converted to useful products like bags, water bottle holders, purse, wallets, etc.

Another example of a recycling company is BLOWPLAST in Accra which recycles water sachet bags into other plastic bags.

3.3.1.3 Scrap metal recycling

Tema Steel Company established in 1960 has been recycling waste scrap metal into iron bars for utilization in the building industry. The company collects between 180 tonnes and 200 tonnes of scrap metals mainly from the "Agbogbolshie" market which has developed into a scrap metal market. Even though there are others who recycle scrap metal into grinding plates, their activities are uncoordinated and hence very difficult to monitor and quantify. The company processes the scrap metal into finished products by melting the scrap metal in a furnace and refining it using an electric arc furnace. No other technology is employed in the refinery process.

3.3.1.4 Composting

As previously mentioned, the country has experimented with centralised composting plants before. Even though the economics did not favour these establishments and lead to a total collapse of the system, the country has not yet given up on composting as a way of reducing the percentage of organic waste entering the landfills. Zoomlion, with the assistance of the Government of Ghana (GOG), is establishing a 300 tonnes per day compost processing plant at 'Medie' in the Eastern Region of Ghana. The plant will have on-site separation equipment which will separate out the organic fraction from the waste.

3.3.1.5 Final disposal

The Kumasi Metropolis is the only city in Ghana that can boast an engineered landfill. The landfill site is situated at Dompoase in the Bosomtwi district of Ashanti Region. Apart from the landfill cells, it has a sewage treatment plant and a system for collecting the leachate from the solid waste for treatment in the sewage pond. The landfill has a 15-year lifespan, after which it will be sealed. Compaction of waste is constantly taking place to reduce the volume of waste in each landfill cell using a specially designed compactor. At present the gas produced as a result of the biomethanation process or fermentation of the organic component is not captured although there are wells installed to aid in the collection of gas. All municipal waste is brought to the landfill site without any sorting or waste segregation taking place.

3.3.2 Best organizational practices

Zoomlion Waste Management Company Limited has grown rapidly from being a small waste management firm in Accra, to being present in almost every district, town and village in Ghana. This success has been achieved partly because of very good and pragmatic organisational practice and partly due to a strong partnership between the firm and the government. In an effort to provide jobs for the youth, the government started a youth employment programme. Initiatives that focus on waste management have been managed by Zoomlion e.g. the 'Ecobrigade' which seeks to clean the beaches of Ghana. Zoomlion's success can also be attributed to its heavy dependence on cheap Chinese technology in the form of skip trucks, compactors, tricycles, etc which have enabled them to cut costs considerably. Instead of importing all of the equipment into the country, they have set up an assembly plant for waste collection tricycles in Ghana. Their engineering department has also been able to motorise some of the tricycles using alkaline batteries. The introduction of tricycles into Ghana has made places previously inaccessible due to the poor road network now within reach. Personnel of Zoomlion are constantly exposed to international best practices through the attendance of seminars and international conferences on waste.

Having recognised the lack of waste management training in Ghana, Zoomlion is on the verge of establishing the only waste management institute in the country, and perhaps the sub region, to train waste management personnel. So far all the technical hurdles like registration and accreditation by national accredited bodies have been surmounted and the waste management institute will soon be operational. Zoomlion has already established an electronic library on waste management with the help of the Council for Scientific and Industrial Research, Ghana. The e-library has about 5 000 well acclaimed books on waste management available. This additional knowledge base will be very useful for the waste management industry.

In order to extent their collection service into the realm of waste management, Zoomlion now owns and operates its own landfill sites. Though these are not engineered landfill sites it is a first step since they are the only waste management company so far to establish landfill sites in Ghana.

The issue of finance has always been the biggest problem faced by waste management companies. More often than not they depend solely on government subsidies which either come in trickles or very late. As a result there are ongoing problems with raising cash for payment of salaries, repairs and even to purchase new trucks or equipment to replace worn out ones. This has led to the collapse of many waste management companies in Ghana. Having recognised this problem Zoomlion have ventured into alternative income generating activities. They are now implementing the government's Green Ghana Programme where the youth are engaged in planting trees as a re-forestation drive to replenish lost forests. Since trees are carbon sequesters, they combat global warming by absorbing carbon dioxide. This qualifies as a clean development mechanism project so the quantity of carbon dioxide saved/sequestered can be traded on the international market. This will bring additional income to the company. Zoomlion also intends using the compost produced from its compost plant as organic fertilizer on farms that produce organic products for export, to raise additional income for the company.

3.4. Evaluation and adaptation of examples from Senegal

3.4.1 Successful technologies

Pre-collection

In general, collection systems adopted by cities are not adapted to the urban layout and are not able to cover all neighbourhoods. To address the lack of collection, grassroots organisations have set up pre-collection systems in several areas in cities.

For example, in some districts, youth and women's associations carry out pre-collection by gathering waste deposited in bins or empty rice bags and leaving them on street corners. From there, horse-drawn carts collect and transport the waste to a point where a rubbish collection truck is waiting.

One such example is the GIE New Vision[7] which has four carts and twenty staff working on household waste collection. It operates in ten districts and collects an average of 10 to 15 tons of waste per day. Each household contributes 2.5 euros per month:

In the Saint-Louis region, pre-collection is carried out by 15 GIE who use horse-drawn carts. The collected waste is taken to the Darou transit site or to containers located along the Langue de Barbarie.

Collection

The organisation of the urban solid waste collection sector varies depending on neighbourhood characteristics and the size of the area, human, material and financial resources and infrastructure. In the Dakar region, 4 collection methods were identified:

- Door to door collection in areas where infrastructure allows normal flows of vehicles to almost every doorstep. In this case, housewives will leave waste by the side of the road at points convenient for the rubbish men to load the waste into the waste compressing trucks and skips,
- "Group" collection takes place in areas where road infrastructure does not allow for door-to-door collection. In this case, the local authority and residents agree on assembly points, at which common facilities (containers of varying sizes) are placed and waste collection trucks honk their horns to inform the residents to bring out their waste to the collection point. Such collection points have been established so that they each cover a radius of 100 m in Dakar

[7] GIE – Economic Interest Group

and 300m in the suburbs. The same collection method is often applied for markets, halls, fairgrounds etc.

- Pile collection: more often known as mechanised collection, because in most cases it involves heavy machinery including, for example, tractors and large capacity open air trucks. This type of collection targets illegal waste dumps which often occur through a lack of awareness or consideration of collection systems in place, or to address the cumulative waste deficit requiring the larger scale machinery to bring it back to level zero. This type of collection reflects the failure of a system since it is not part of the panoply of standardised data collection activities,
- Private collection carried out either by private individuals their own equipment at home, different from those related to household or industry waste. This practice is done either by dealers who, in addition to their activities in the system, organise private collection circuits with these waste producers, either through a private collection with pernicious effects because it does not take place through an agreement with the company, but simply through direct agreement between the crew, the waste collection truck driver and maybe even involve lower level management.

Street cleaning is carried out manually by sweepers equipped with sweeping equipment. To organise this service the Dakar Region is split into several layers: technical, area, region and routes departments. There is also a Rapid Response team to remove any unplanned waste and a team to go over the major transport arteries.

Plastics recovery

Formal initiatives for plastic recovery are still rare. However, some examples of good practice are beginning to emerge, such as the NGO LVIA's establishment of a plastics processing centre in the region of Thies. The centre employs women to clean, grind and package plastics that are then sold on to processors.

In the suburbs of Dakar, women's groups are also active in the recovery of plastic waste. Collection shops are set up where the women buy a kilogram of plastic for 4 euro cents to then sell it on to the recycling industries of plastics at 95 euro cents.

Before resellling, the plastic is sorted, cleaned, cut and ground. This work pays between 2.5 and 3 euros per day.

Elimination

Only in the St. Louis region is there a technical landfill site for waste disposal. In other regions, waste is taken from Dakar to undeveloped informal dumps. The biggest of these is the Mbeubeuss landfill which receives some 1,500 tons of waste per day.

Processes involve displaying, sorting and compressing the waste dumped on a daily basis at the arranged unloading platform.

The displaying, sorting and compressing is carried out by a D8 bulldozer. However, when it rains the bulldozer is assisted by a 950 loader.

The closure of the Mbeubeuss landfill is scheduled for August 2011. A waste transfer centre and a technical landfill site are under construction.

The landfill receives approximately 800 Mbeubeuss waste collectors. Its closure comes with an action and resettlement plan prepared according to procedures developed with the World Bank (OP12), a project partner. As such, the plan is to relocate 350 of the waste collectors to the waste transfer and sorting centre. They will organise themselves into an operating company.

The sorting section will be semi-automatic with the use of conveyor belts. Beyond the economic reintegration of some waste collectors, sorting will also significantly reduce the quantities of waste to be buried at the landfill and as a result also reduce costs. This sorting and transfer centre will be the first of its kind in West Africa.

Unsorted waste will be transported to the Sindia technical landfill site. Construction is underway and will include the establishment and equipping of 3 compartments and lixiviation pools; rain and lixiviat water drainage; an internal road system, administrative buildings and technical works; biogas collection and disposal.

The first compartment is also available. Operations are due to start in August 2011.

The development and operation of these two centres has been outsourced to a private consortium under a BOT mechanism. The concession period is 5 years.

Since 2009, Senegal, and the Dakar region in particular, has embarked on a policy drive to improve solid waste management. Thus, the CADAK/CAR Agreement which brings together local authorities in the Dakar region (4 cities, 3 suburb districts and 2 rural communities) has requested technical support from the African Institute of Urban Management (IAGU) to help develop a strategic plan for integrated and sustainable solid waste management.

The overall objective of this exercise is to provide the Dakar region with a shared vision, a strategy and an action plan to ensure sustainable and integrated urban solid waste management.

As such, the history of the institutional and regulatory framework and the technical analysis of waste management have been made. These documents have served as a working basis for the planning workshop held with all stakeholders to discuss different strategies and action plan for sustainable solid waste management in the Dakar region.

The plan will be adopted by the authorities in August 2011 and will be accompanied by a five-year action plan.

The city of St. Louis and the secondary cities of Matam, Podor, Darou Salam have the support of the cooperation of the Grand Duchy of Luxembourg for the establishment of municipal technical services, including a division dedicated solely to managing waste.

3.5. Evaluation and adaptation of examples from Nigeria

3.5.1 Successful technologies and best organisational practices

As already stated in WP 2, Nigeria has an existing legislative framework for the management of the environment that includes solid waste management. As highlighted in WP 2 these laws are not enforced and compliance levels are comparably low. The culture of non-compliance is also found among institutions responsible for the management of solid waste in Nigeria. There are many policy gaps within these institutions.

The aim of this task is to provide guidance on the selection of best organizational practices in the management of SWM in Nigeria.

The local government (LG) is the closest tier of government to the people and so the activities of the LGs have more effect on the citizenry than activities at the state and federal level. Unfortunately, local governments are excluded from participating in the legislative review, revision and redrafting process. This limits local-level inputs into the legislative process, thereby decreasing local-level institutional awareness of, and ownership over, environmental management and protection. It is suggested that the LGs should be included in the legislative process around SWM.

Although there are various government institutions and agencies responsible for SWM in Nigeria, there is no coordination amongst them. There are no clear guidelines setting out the relationship between existing institutions and Agencies.

The role of the informal private sector in SWM cannot be over-emphasized. The cart-pushers are an important part of this sector in Nigeria. However there is no formal framework regulating the activities of the informal private sector in SWM, and hence there is little or no coordination between the private sector and government or government agencies. It has been suggested that the government agencies, particularly State Environmental Agencies (SEPAs), work out a framework to incorporate the cart-pushers, thus making them responsible to the agencies.

3.5.1.1 Technical Solutions

As is often the case in developing countries, the waste management situation in Nigeria is characterized by five typical problems:

- inadequate service coverage;
- operational inefficiencies of services;
- limited utilization of recycling activities;
- inadequate management of non industrial hazardous waste; and
- Inadequate landfill disposal.

This section discusses some of these problem areas and suggests possible approaches for improving the situation.

The goal of collecting data on solid waste (quantification and characterization of various waste streams) and existing management systems (collection, transportation, treatment, disposal, recycling and recovery) is to develop an integrated solid waste management plan. Solid waste management may vary from country to country and city to city. In Nigeria, the local governments are responsible for municipal solid waste management (albeit with a lot of help from the State), while industrial and hazardous solid waste are the responsibility of Federal government. In practice however, the State and different department within local government manage the three kinds of wastes simultaneously. It is recommended that the data be collected separately for different types of waste management systems even if there is some overlapping in terms of regulations and laws, financial mechanisms, technology and infrastructure and stakeholder participation.

There can be no universal panacea to the challenge of solid waste management. Each solution must be adapted to suit the specific features of the particular area. No doubt the issue of SWM involves the application of sound and appropriate technologies and organizational efficiency.

It is important to state that the terrain in Nigeria is such that no two zones are so alike that they could be called homogeneous. Therefore a SWMS that has been tried and tested in one zone may fail completely in another. Many technologies that have proven successful in the developed countries have been imported into the country, but they have not yielded the expected results. In Lagos State (south west Nigeria and the federal capital territory of Abuja), the adoption of the PSP (Private sector partnership) has proven to be a more successful WM initiative with the use of modern compactors for the transportation of municipal waste and different types of bins .

Nigeria is made up of six geopolitical zones situated mainly in the north and south, excluding the federal capital territory, Abuja. Below is an appraisal of existing technologies and organizational practices identified in each zone along with analysis, comments on their performance and subsequent recommendations for suitable systems for SWM.

3.5.1.2 Geopolitical Zone: North West

Existing Technologies

- Manual collection systems with metal boxes (serving as bins), personal bins and compaction trucks.
- Authorized (or unauthorized dumpsites)
- Incineration
- Small scale resource recovery.

Current Organisational Practices

At the National level, the Federal Ministry of Environment and NESREA regulate waste management and there are a number of regulations for different sectors.

State environment protection agencies and waste disposal authorities like Kano State Refuse Management and Sanitation Board (REMASAB), Kano Waste Management Board, Kano State Environmental Planning and Protection Agency (KASEPPA), Rural and Water Sanitation Agency (RUWASA), and Kano state Ministry of Environment, carry out waste management activities in Kano state.

There are no separate agencies for e-waste or industrial waste management besides those listed above.

Kano has over 320 industrial establishments comprising of chemical and cosmetic industries, tanneries, textiles, and food processing factories.

Few operating industries have treatment facilities for their wastes; the small scale industries are often unaware of existing laws and are not serviced by the management agencies.

Performance Analysis

In practice, most of the waste management agencies are primarily concerned with domestic waste and have not developed a system for processing, monitoring or controlling the management of other waste streams.

Service coverage is low; focusing mainly on the urban centres and the zone experiences continued unauthorized dumping.

Solid wastes and effluents from industries are continuously discharged into the environment, resulting in poor water quality.

Best practice recommendations

Enforcement of existing laws and policies on waste management especially at the household level is essential.

Segregation, treatment and recovery processes should be developed and incorporated into the system.

Local government authorities and community leaders should be involved in the waste management process. Indigenous, cost effective ways for collecting and transporting waste should be developed and implemented.

Industries should be made more responsible and accountable for proper disposal of their wastes and it is suggested that a monitoring team be brought in to interface with them. Small scale industries that may not have the capacity to establish adequate treatment facilities should be supported by a waste management agency.

The informal sector involved in resource recovery should be regulated and assisted to establish a working relationship with industries and in setting up buy-back recycling centres.

Policy framework and strategies should be decentralized and accommodate input from and local and indigenous leaders especially in the rural and semi-rural areas

3.5.1.3 Geopolitical Zone: North East

Existing Technologies

- Composting (sometimes mixed with human wastes);
- Authorized and unauthorized dumping

Current Organisational Practices

State agencies such as Borno State Ministry of Environment and Borno State Rural Water and Sanitation Agency are in charge of solid waste management in this zone. Their focus is mainly on domestic wastes.

Borno State's economic mainstay is agriculture. There are also shoemaking, ornamental leatherworks, glue, and gelatine, and export industries.

Industrial and agricultural waste management practices are poorly regulated and contribute to environmental degradation.

E-waste management has not become a separate focus area in the waste management process.

Performance Analysis

Unauthorized dumping continues on land and in water sources. Protection agencies have not been able to get a grip on the sanitation situation. This is partly due to the lack of basic infrastructure, e.g. sewage facilities.

As a result there are faecal wastes present in domestic wastes that are discharged indiscriminately into the environment.

Industries, especially small scale ones, are unconcerned about proper disposal and are largely unaware of existing laws.

Best practice recommendations

Enforcement of existing laws and improving the segregation and treatment processes.

Facilitation of wider service coverage and effectiveness in cooperation with rural people and community heads.

Regulation and monitoring of waste management practices of organizations and provision of incentives or command-control methods for compliance.

Building of environmental awareness in farmers and the establishment of waste composting activities to improve agricultural productivity.

The use of landfilling practices that do not contribute to land degradation.

3.5.1.4 Geopolitical Zone: North Central

Existing Technologies

- Collection (using wheelbarrows especially in semi-urban areas) and compaction trucks and vans in the urban areas.
- Open air burning
- Authorized and unauthorized dumping.
- Land filling (location of such sites is still a challenge)

Current Organisational Practices

The economy is agriculture based, with an emphasis on cotton, guinea corn and ginger. The economy also supports cattle trading, brewing, Shea nut processing and gold mining. Traditional industries and crafts include leather work, metalworking, and cloth weaving.

The environmental protection agencies here still struggle to provide adequate with domestic waste management services, let alone industrial or e-wastes. For example, cattle trading and abattoir activities produce wastes that are left either to run into water sources or public drains, or these are dumped indiscriminately.

Performance Analysis

Waste management authorities have low service coverage and private service providers offer services to a limited part of the public.

Best practice recommendations

The PSP efforts here should be restructured to include all areas and adopt a system of collection and processing that suits the topography and living conditions of different areas.

Recycling activities should be supported, especially in the area of crafts.

The state ministries of environment should monitor wastes discharged by industries and provide services for them at agreed prices. Regulations around sanitary standards should also be enforced.

NGOs and community organizations have a role to play in educating, and raising awareness about lawful and right waste management practices.

3.5.1.5 Geopolitical Zone: South East

Existing Technologies

- Collection routines with refuse bags and compaction trucks.
- Authorized and unauthorized dumpsites
- Resource recovery and recycling activities.

Current Organisational Practices

The South East region is known for its thriving economic activities. There are many industries, both large and small scale. These organizations have little or no consideration for waste management in their activities.

Wastes are dumped indiscriminately by organisations and households, and become unsightly heaps by roadsides or in gutters.

There is little awareness of the issue of electronic waste (e-waste) or the potential danger posed by inappropriate handling of e-waste. Activities and trade in used electronic equipment is carried out with no concern for the potential health risks.

Performance Analysis

Environmental Protection Agencies or Waste Management Boards in the area have yet to enforce organizations' compliance with waste management laws.

There are a few private businesses involved in waste management and much of the recycling activities are done by the informal sector.

Best practice recommendations

Enforcement issues must be addressed

Industries in all sectors must be made responsible for managing their wastes and surrounding environment, with either command-control or economic incentive mechanisms. Besides having an enforcement role to play, Agencies must also serve as an educator and trainer for these industries, especially SMEs.

The waste management system must be improved with public education and participation as a starting point.

Existing recycling activities must be supported by the state government and an integrated solid waste management strategy must be developed in cooperation with the formal private sector.

Structures in the form of institutions and skilled personnel must be created to deal with e-waste especially in the big cities like Awka, Enugu, Onitsha and Owerri.

It is important that local government authorities be involved in the establishment of waste management services that extend beyond just the urban areas, and that utilise locally appropriate methods of collecting and transporting wastes.

3.5.1.6 Geopolitical Zone: South West

Existing Technologies

Collection and transportation by waste authorities or the informal sector.

- Land filling and composting
- Incineration

- Recycling and resource recovery

Current Organisational Practices

Lagos is the commercial nerve centre of Nigeria and is home to about 68% of Nigeria's industries. Organisations here have been under supervision by the appropriate protection agencies.

Some of the major industries in this region include cigarette manufacturing industry, brewing industry, furniture making industry and agricultural products processing industry (e.g. Ibadan trades in major agricultural products like cocoa, rubber, timber, palm oil and cassava.)

There is also a market especially among the small scale industries, for recycled materials. Thus, recycling activities are on increasing in this region and are a source of employment for the youth.

Partially or untreated effluents and other solid wastes, however continue to be discharged into public drains, onto land and into the air from small, medium and large scale industries. There are inadequate precautions taken at disposal sites to supervise and ensure proper sanitary conditions.

The electronic and electrical sector has remained unregulated, with wastes from used goods and defective imports being dumped indiscriminately. All management of these wastes takes the form of informal salvaging and recycling activities.

Performance Analysis

The states in this region have made considerable progress especially in public private partnership schemes.

There has been an improvement in domestic waste management however inadequate monitoring and control of industries' waste disposal practices have led to the continuous pollution of groundwater and watercourses, and are responsible for the high level of heavy metals in fish.

E-waste management is still undergoing policy development. Lagos state has pioneered initiatives for addressing e-waste issues in partnership with the private sector.

Best practice recommendations

Population growth in this region necessitates a commensurate increase in all relevant agencies' capacity to ensure that waste service provision is efficient and covers not just the upper income areas. Private Service providers should be regulated to offer affordable services that are suitable to the serviced area.

Local government authorities must play a role in educating and enforcing laws not only in the rural parts but also in slum areas of the big cities.

Industries must be made liable for their waste disposal practices through effective compliance mechanisms. Periodic checkups must be conducted to verify that treatment and anti-pollution equipment is in working condition. Where laws are flouted, apart from economic penalties, the areas affected should be cleaned up at the cost of the particular industry.

Small and medium scale industries that may not have the wherewithal to manage their wastes sustainably could be assisted by the government agencies at a fee. Corporate social responsibility (CSR) of organisations in the places they operate must be emphasised to assisting in giving infrastructural amenities that would support the waste management process.

Landfilling systems must be engineered to be sanitary and unauthorized littering and dumping should be controlled with overt acts of penal and economic sanctions Special care must be taken to situate landfills away from residential areas; a task which might prove difficult owing to the massive rural-urban migration in that region.

In addition, public awareness and education on the dangers of unhealthy waste disposal practices should be a continuous process. The objective should be a situation where health considerations and not just fear of sanctions affects people's behaviours.

Present efforts on e-waste management should be intensified and policies followed through at the state level. In addition, efforts must be made to begin the extended producer (importer or

assembler) responsibility programme since most electronics are imported into Nigeria. Hence, control of imports must not decline.

The most important aspect to focus on would be formalizing and structuring the recycle activities in this region to provide employment and create wealth. The informal sector should be supported as part of the organizational structure.

3.5.1.7 Geopolitical Zone: South South

Existing Technologies

Collection is not done by the waste authorities but taken to designated points by the people themselves. Tipper vehicles and trucks are used for transportation.

Landfilling often consists of the disposal of both domestic and industrial wastes

In rural areas, the people resort more to burying, burning, open dumping and disposal of their waste into the rivers or streams.

Current Organisational Practices

The South South region, popularly known as the Niger Delta region, is home to the oil and gas industries in Nigeria. Their operations have resulted in the abundance of gaseous, liquid and solid wastes such as lube oils, papers, printer cartridges, food wastes, glass, batteries, tyres, associated gas, drill mud and cuttings, produced water etc. This also includes waste from other industrial establishments, local markets and households.

Performance Analysis

The ubiquitous nature of the oil industry, particularly in the rural areas, means that the waste management problem in the Niger Delta is not primarily an urban dilemma, as in other parts of Nigeria; but also a problem of the rural areas.

Environmental Agencies' efforts have yielded few results in the urban and especially the rural areas. The big cities in the region like Warri, Uyo and Port Harcourt still have waste disposal problems.

Best practice recommendations

There should be ongoing education and awareness creation on waste management, particularly in the rural and semi-urban areas. The relevant authorities responsible for the management of waste need to enhance their capability on the effective implementation and enforcement of the existing laws.

The oil industries should be involved in bioremediation processes in partnership with the agencies to clean up polluted sites in the rural areas. Standards for waste management should be complied with.

The private sector as part of their Corporate Social Responsibility activities can provide facilities for waste management particularly in the rural areas and semi-urban areas.

There are few passable roads in the rural communities. Therefore alternative technologies for collection need to be developed to facilitate collection and transportation of wastes in these areas. It is suggested that the cart pushers be incorporated into the activities of the waste management services in these areas. Also, the use of boats can be developed. This should involve the locals especially the youths for a commission. This would create additional employment for the youths and also be a strategy for calming the restiveness among the youths in that area.

Recycling activities should be bolstered especially in integrated fish farming which is a major source of livelihood for these people. This would no doubt include public education by NGOs and CBOs

3.6. Evaluation and adaptation of practices from Côte d'Ivoire

3.6.1 Successful technologies

3.6.1.1 Primary collection

Côte d'Ivoire's rapid population growth rate and increasing urbanization intensified the government's efforts to improve basic urban services for its population. The Urbis program focusing on the state's efforts to improve the quality of life in Abidjan's slum was initiated. This was done by providing the Federation of Solid Waste Pre-Collection (FEPSUCI), a group of 3,600 slum dwellers, with training and technical assistance to amplify the voice of pre-collectors, enhance the quality of their services and increase their incomes and job stability.

At the start of the program, the government had hired multi-national and Ivorian companies to collect household waste. These firms relied on the services of pre-collectors, such as FEPSUCI, to pick up trash in the city's poorest neighborhoods, but did so without formally contracting them. FEPSUCI members claimed they were underpaid because of this arrangement, earning a seventh of what they could earn if they were contracted directly by sanitation authorities. In August 2008, after a year without pay, FEPSUCI members went on strike. They demonstrated to raise awareness about the abusive relationship between slum-based pre-collectors and large sanitation firms, the absence of laws to regulate the sector and the lack of recognition for their services. FEPSUCI's informal status, however, prevented its members from accessing formal contracting mechanisms set up by the state.

FEPSUCI's coverage is impressive as it operates in 10 of Abidjan's 13 communes, servicing over half of the city's slum dwellers. Out of Abidjan's 4.2 million inhabitants, an estimated 830,000 inhabitants in slums and benefit from the services of pre-collectors, who collect approximately 1,000 metric tons of refuse a day.

Given the government's plan to improve the national sanitation sector, the Urbis program was well-timed. Urbis built the capacity of FEPSUCI so that its members could compete for public tenders. This entailed providing key members of each of FEPSUCI's 32 cooperatives with the technical, organizational, legal and financial skills they needed to convert their informal organizations into ten slum-dweller owned businesses. Furthermore, the Urbis team, which included the well-known parastatal entity like the Bureau National d'Etudes Techniques et de Developpement (National Bureau of Technical and Development Studies, or BNETD), FEPSUCI and DIG, worked with city and government officials to help pre-collectors gain formal recognition and incorporate slum trash collection into public sanitation bids.

Through the Urbis project, pre-collectors became aware of their essential waste collection role, which enhanced their ability to communicate with the government and bring about improvements for their members and clients, most of whom are slum-dwellers. The Minister of the City and Sanitation and the President's Advisor on waste management issues reacted positively to their advocacy effort, publicly recognizing that the pre-collectors' waste removal services were indispensable. This formal recognition was a step in paving the way for FEPSUCI to compete for market. Through training and technical assistance in business administration, financial management, contract drafting, and resource mobilization, Urbis provided the managers of FEPSUCI's cooperatives with the basic skills needed to register legally as businesses and manage those businesses effectively. By the end of the program, the informal trash collectors had successfully registered business corporations.

In January 2011, three informal trash collector firms have been awarded municipal contracts to collect household waste and clean up streets and gutters in their respective communes (Marcory, Bingerville and Plateau). These contracts generated 332 employment opportunities for pre-collectors and US$ 271,840 in combined revenue. As a result, the living conditions of 70 684 slum dwellers serviced by these firms improved. The salaries of the waste collector managers also increased by 150% (from USD 195 to USD 485 per month).

3.6.1.2 Waste Collection

The project "Clean City" component of Emergency Program "waste management" of urban infrastructure is an example of success in collecting solid waste. This project began in 2009 with support from the World Bank and involved 13 municipalities in the district of Abidjan, the economic capital of Côte d'Ivoire. The district was divided into six lots for the different operators selected. The total project cost was estimated at $12 million.

The main objective of the project "Operation Clean City" was to strengthen the collection, removal and disposal of solid waste in Abidjan in order to help improve public health, and the life conditions of the inhabitants in the city. Specifically, it aimed to collect and transport to landfill approximately 560,000 tonnes of household waste from 13 municipalities of the District of Abidjan over a period of three months and rehabilitate all safety sites and deposits to be rid of garbage. In addition:

- updating the repository sites;
- rehabilitation of site;
- designation of site grouping;
- inventory of pre-collectors;
- Awareness building of the population.

The success of this project in the area of collection is certainly linked with and funded organisation implemented. Indeed, for the implementation of this component on the solid waste management, it was established two committees:

- Monitoring Committee

  This committee is composed of representatives of Ministries (ANASUR) and coordination of Mayors). Its role is to supervise the activities and validate studies.

- Local Committees

  They are chaired by the Mayor of the municipality concerned. These committees have an oversight role, monitoring and certification of operators' work. They are also raising awareness at the grassroots level.

The work program adopted in accordance with the various stakeholders is:

- inventory tracking, illegal dumping and updating and validation by the Local Committee;
- proposal by the technical operator of the intervention program and field equipment approved by the Local Committee, taking into account the comments of the Commune;
- Establishment of intervention teams: teams for removal and rehabilitation;
- Validation by the technical unit of the weekly program of work on the land proposed by the technical operator.

The various operations were supervised and monitored by independent inspectors appointed by the MACOM (Mission of Support in the conduct of municipal operations), the body responsible for managing the project.

The World Bank has allocated nearly $12 million for the solid waste management component in the District of Abidjan.

As main results on the ground, nearly 250 illegal dumps have been identified, removed or rehabilitated in the District of Abidjan. Several centres groupings were created or rehabilitated. The projected quantity of waste was 500,000 tonnes in 3 months. Operation "Clean City" helped to remove about 98% of the projected quantity of waste. It is noted that the collection rate was 75% in 1989; it fell to 65% in 2000, and finally stabilizing at 46% in 2006. This project has had remarkable success in the implementation. It was therefore continued until December 31, 2009 and 2010 with "Operation Clean City, Phase 2." In 2011, after a post-election crisis, the new government has implemented an emergency program which includes a presidential management component of solid waste. This new operation "clean city" aims to make the landfill of 200,000 tonnes of

household waste to be collected in 13 municipalities of the District of Abidjan over a period of three months.

3.6.1.3 Disposal

Currently there is no properly engineered landfill site in Côte d'Ivoire. The waste disposal site of Akouédo, located 16 km from downtown, on the road Abidjan-Bingerville accommodates all waste from the District of Abidjan.

A new landfill site located Attiékoi (Anyama) is under construction. The site covers 123 hectares, and has a specific geological structure. The landfill site, operated by the company IMPEX PISA provides a pool of garbage disposal, facilities for water drainage and for protection of groundwater. A geomembrane of 2 mm thick, material with high impermeability will put in place during construction for the protection of groundwater. In addition, facilities for the production of biogas are already installed and will be reinforced in the coming years.

Land conflicts and socio-political situation in Côte d'Ivoire have delayed the beginning of the landfill site construction since 2002 and it continues today.

3.6.1.4 Waste recovery (Recycling/treatment/composting)

In Côte d'Ivoire, various projects on the development of solid waste have been implemented. The technologies have been implemented by companies in the field of plastic waste. Other companies began production of biogas from waste dumps from the District of Abidjan. In addition, the socio-political context that befell the country has significantly slowed the practical implementation of some projects on solid waste.

Plastic waste

Plastic wastes are from different sources: waste processing, packaging waste industry and retail centres, automobile contained useless, garbage, etc. In addition to the landfill or incineration of waste plastics, there is the option of valorization to fight against the unhealthy.

In Côte d'Ivoire, the valorization of plastic waste start with the pre-collectors set up in various places of discharge. The main area frequented in the District of Abidjan remains the discharge of Akouédo. The plastic waste is routinely collected by a large number of pre-collectors. The items collected are either sold directly to intermediaries who will clean them, wash them and then resell to manufacturers, located in the industrial zone of Kumasi and Yopougon, or they are washed and sold directly to companies for manufacturing plastic items.

In most cases, the process goes from the collector to the industry through an intermediate agent (wet scrubbers are often collectors themselves) but often, the plastic wastes, especially the bottles, are cleaned, washed and sold directly to persons engaged in commercial activities involving the packaging bottle.

The factory is the place for final recycling of plastic waste which is the valorization process. It can be done mechanically or chemically. Mechanical recycling is to consolidate the material to produce marketable products. The waste is rewashed, transformed into a powder which is later converted directly into finished products. This process is simple when the plastics are of the same composition.

In the factory TIP sarl, in the industrial zone of Yopougon (District of Abidjan), the 200 tonnes of plastic waste purchased each month, preferably all polyethylene, is not mixed with other plastic types. Indeed, recycling is a problem when the plastics are of different composition as they are not compatible because the transformation temperatures are different and a mixture of several plastic results in a decreased quality of the mechanical characteristics of the final product.

The chemical transformation is also an option but it is not well developed in Côte d'Ivoire because of the high cost. It involves breaking down the constituent macromolecules of polymers in reusable materials. The plastics are depolymerized under the influence of heat and/or a chemical compound. According to the method used, the material returns to the starting monomer or basic petrochemicals.

Several companies are carrying out the valorization of plastics in Côte d'Ivoire. Most of them are TIP LLC, Kim and CI-Plastic-plast (Society of Plastics Processing). Two industrial zones are mainly concerned: Yopougon and Kumasi.

The final products are very varied: cooking utensils, roof sheeting for ceremonies that punctuate daily life (holidays, funerals), footwear, packaging, garbage bags, buckets, shovels, etc. In fact, with plastic waste, we can reproduce the same objects. It is also possible to manufacture farm equipment. This is particularly the case of CI-PLAST that produces nursery bags and rubber cups.

Agricultural residue (cocoa shells)

The proposed co-generation biomass (Meagui city, south-west of Côte d'Ivoire) a promoter for the ANADER (National Agency for Rural Development Support). This project is important in the management of waste from the cocoa business. Indeed, this activity generates large amounts of waste. For example, 1 kg of cocoa generates 8 kg of solid waste. This project not only solves the problem of crop residues that could pollute the environment but will also improve farmers' incomes and the quality of cocoa for a label cocoa, Côte d'Ivoire. It will provide heat for drying cocoa and produce electricity for farmers. According to experts, the co-generation system Meagui (Ivory Coast) will have a total capacity of 557 KW.

Discharge Akouédo (Distric of Abidjan)

The company "Group Eoulée-Cegimar" as part of the valorization of municipal waste to rehabilitate the landfill Akouédo (Centre Technique d'Abidjan landfill) and for the development and operation of biogas extraction.

The landfill is located precisely in Akouédo on the road Abidjan-Bingerville. This dump is huge and unique, consisting of a natural ravine that stretches from north to south, on 100 acres of surface and 25 meters deep on average. From 1965 to 2004, a total of 20 million tonnes of waste was dumped into the ravine by the municipal services taking up 80% of its total capacity. Located in the middle of town today, the release of landfill gas and leachate can generate significant harm to the health of local populations and pollute the groundwater and surface water lagoon Ebrie nearby.

This project of valorization of municipal waste, managed by the company "Group Eoulée-Cegimar", began in 2005. The overall objective of the project aims at servicing the polluted site of the landfill Akouédo to make it available for other uses, while exploiting biogas for energy for several more years. Based on this overall objective, there are three major components to this project, each with distinct objectives, namely:

Component 1: Environmental Remediation of the landfill Akouedo

The objective of component 1 is to plan and carry out the containment of the 80 acres of polluted land, fully saturated with waste, for safe closure of that part of the landfill Akouedo. This will involve the environmental remediation required to monitor discharges and pollution, as well as putting in place the appropriate environmental monitoring systems.

Component 2: Recovery and utilization of biogas

The objective of this component is to capture the biogas generated by anaerobic decomposition of waste stored at depth and to enhance the biogas into electricity.

Component 3: Introducing a new approach for the treatment of waste

The objective of this component is to provide municipalities a new method of treating waste in Abidjan agglomeration. This comprises a triage unit of 3,000 tons of waste per day and biodegradable waste selected to optimize biogas production on a new 50-hectare site adjacent to the current site (at end of operation) according to international standards.

At present, the company "Group Eoulée-Cegimar" has already completed the exploration of biogas. Indeed, eight wells were drilled in the area of 80 hectares of polluted land and biogas production is 11,045 m^3/day. This biogas is composed of 50% methane.

This project should permit long-term creation of nearly 6,000 jobs. Added to this are many economic, environmental and social projects for populations living near the landfill Akouédo. Once

implemented, this project of revalorization of municipal waste will end the suffering of local residents by cleaning up their surroundings and allowing the marketing of many products such as methane, electricity and even organic fertilizer.

3.6.2 Best organizational practices

At the organizational level, Côte d'Ivoire has an Agency (National Agency for Urban Safety) which is responsible for managing solid waste. The National Agency for Urban Safety (ANASUR) is a public industrial and commercial agency created by decree No. 2007-587 of 4 October 2007. It is under the technical and administrative supervision of the Department of City and Urban Sanitation and the financial supervision of the Ministry of Economy and Finance.

The creation of the Public Agency has to have a single point in the waste sector in Côte d'Ivoire. Indeed, this sector is characterized by a multitude of institutional actors whose role is barely visible. ANASUR is a regulatory agency with the following roles:

- Regulating the operation of the waste stream with impact on urban health;
- Regulating the concession of public service cleaning, towns and districts of Côte d'Ivoire;
- Regulating the right treatment and processing of waste;
- Monitoring the proper functioning of the infrastructure granted by the State to third parties or communities for the transfer, sorting and processing of waste;
- Organization and management of emergency operations;
- Managing the fund to support urban health programs;
- Leading the fight against unsanitary practices and nuisance;

ANASUR's mission is to implement the national plan for urban safety. As such, it provides:

- planning, extension, infrastructure equipment for urban health;
- mastery of delegates from all works of maintenance and rehabilitation of infrastructure;
- Assistance to communities and monitoring of compliance with the regulations of the intervention of service providers for public safety.

Thus, the Public Agency supervises the various emergency projects (Operation clean city) of the World Bank in Abidjan District. In secondary cities, the ANASUR has signed an agreement with Care International to grant to the NGO the right to service ensures public safety in the cities of Bouake, Korhogo, Man, Duékoué and Bondoukou. This has significantly contributed to improving the lives of people resident in those cities. ANASUR Agency, operational, main contractor, the structure was commissioned by the Ministry of Youth, Sports and Sanitation for Urban Management and control of project implementation. This project thus undertakes to:

- Organize Committees of Safety to ensure the pre-collection of garbage, including daily removal of garbage from households, businesses and government;
- Rehabilitate 50 storage centers on 80 previously conducted in the cities of Bouake and Korhogo;
- Build 60 new centers, including 30 in the town of Man in western countries, 10 in the town of Duekoue, 10 in the town of Bondoukou in the East, 5 in the city of Bouake at the Centre, and 5 in the city of Korhogo in the north;
- Provide transportation to the landfill waste pre-collected and stored in appropriate sites.

4. SUMMARY: SELECTION OF MOST SUITABLE SYSTEMS FOR TARGET COUNTRIES

4.1. Systems Suitable for Municipal Waste Management

4.1.1 Logistical elements

It is necessary to adapt collection frequency to waste generation and overall efficiency of the system. It is therefore necessary to gather data on waste generation and composition, area characteristics, haul distances, availability of spare parts and service facilities, etc.

Collection of metals, glass and plastics (PET) can be the responsibility of the private sector that would be contracted to perform door-to-door collection and guarantee the separation of recyclables wastes. These services could be outsourced to informal sector contractors who could be promoted to work under better conditions. Likewise, households can be encouraged to separate at source through education and economic incentives; Civil Society Organizations (CSOs) should be engaged to work jointly with local authorities to raise awareness and run information campaigns seeking behavioural change on waste sorting. These programmes would be supported by training and awareness materials such as technical guidelines for waste reduction and prevention.

Biodegradable waste should be processed as far as possible in a decentralized system seeking low-cost solutions rather than in large-scale composting plants.

4.1.2 Technical elements

4.1.2.1 Separation and pre-treatment

At household level, it is recommended that West African authorities provide households with specific containers and guidelines for appropriate waste sorting.

The decision to employ mechanical pre-treatment could be of interest since these plants allow the reduction of waste volume. Nevertheless, the absence of mechanical pre-treatment should be taken into account when organic waste treatment is foreseen.

4.1.2.2 Recycling and recovery

Recycling activities and reintegration of secondary resources into new products should take into account the potential of cross-contamination as well as the health risk of recycling activities to workers.

4.1.2.3 Final disposal

Sanitary landfills are best options for disposal. There are different types of landfills according to the final waste characteristics which can be useful in the target countries according to the Swiss experience: landfill for inert materials, landfill for stabilized residues, bioactive landfill.

Incineration is widely used in the European context, however, experience shows that even though there is a high potential for energy production there is also a health risk of emissions which must be effectively controlled.

4.1.3 Institutional requirements

Institutional (non-technical) arrangements might include governance, strategies, legislative framework, organizational and management structures, planning and budgeting activities, in other words the 'non-technical' solutions.

4.1.3.1 Legal elements

It is necessary to ensure law enforcement to implement Integrated Solid Waste Management approaches in the target countries. Additionally, Action Plans must assign responsibilities and resources to perform the necessary tasks and be built on a participatory basis and avoid the frequent duplication of responsibilities amongst different decision makers.

4.1.3.2 Organizational elements

Private-Public Partnerships (PPPs) can be enhanced in the target countries by extending the involvement of the private sector in partnerships with local government. The private sector can set up recycling centres, landfills and incinerators, as well as be made responsible for collection and transportation services. Nevertheless, the public authorities must still play a strong role in controlling and ensuring that solid waste management is done according to the principles agreed with the private sector.

The management of industrial waste and WEEE can be made the responsibility of the respective producers of the equipment. Law enforcement is the main constraint to extending this practice in the target countries. Partnerships and agreements between private and public sector can enhance compliance with the polluter pays principle.

4.1.3.3 Clear division of responsibility between stakeholders

It is imperative that stakeholders involved in waste management have their roles clearly defined. This is to prevent overlapping of roles, which usually results when many stakeholders have an interest in a particular area. The following are some of the stakeholders in waste management:

The national government: These should be involved in the policy making. In Ghana, national institutions such as the Ministry of Local Government and Rural Development are responsible for environmental sanitation policy formulation. During the policy formulation process, relevant stakeholders such as the private waste management companies, research institutions and informal waste collectors must be involved. This is to ensure the proper implementation of the policy. Also during policy formulations, resources and structures should be put in place.

The local government: the local authorities involved in waste management are the metropolitan, municipal and district assemblies. They are usually responsible for providing waste management services. In areas where waste management services are privatized, the monitoring role of the assemblies should be clearly stated. Again the assembly should be equipped enough so that incase of the collapse of the private companies, the assemblies can take on the responsibility of providing waste management services.

Private formal waste collectors: in areas where private owners are totally responsible for the management of waste, there should be contractual arrangements between the local government authorities and the private waste collectors, stating clearly the responsibilities of these waste collectors. Also, there should be regulations where contracts can be withdrawn from these waste collectors in case of failure to do their work. There should be constant monitoring of the activities of the private waste collectors.

Informal waste collectors: They play a very important role in waste management especially in recycling of waste. Informal waste management provides income generation opportunities for the poorest urban dwellers. These are often from underprivileged groups; minorities, immigrants etc. They have historically not been acknowledged by or involved in formal waste management, and it is challenging to involve them in decision making. However, formalizing informal waste workers may be important for national targets in terms of poverty reduction and job creation. One of the ways to make their work effective is formation of associations. In this way, they can have access to loan and other waste management facilities. They are involved in collection, recycling and disposal of wastes, and should therefore be acknowledged as waste management stakeholders.

Households: They should have a major responsibility when it comes to waste management. They must be responsible for proper waste management within and outside their environment, including cleaning and properly disposing of their waste. Households must store their waste properly and pay for their waste collection services in areas where such services are provided. Also all households must be involved, during community clean-ups.

Community-Based Organizations: Individuals within the community can form associations and help the community during clean up campaigns and education. Since they are close contact with the community, it is more likely be effective.

Donor agencies: They play a major role in waste management. They should not impose their ideas on the receiving body. Rather there should be dialogue between the donor and beneficiary so that the objectives of both sides can be achieved. More often than not, the donor agencies have their objective and impose it on the receiving body. Sometimes projects supported by the donor agencies are short term, which is not sustained over the years.

4.1.3.4 Knowledge management, information and communication

Staff employment and training: there should be ongoing on-the-job training of staff on issues such as the use of equipment and health training programs. Results of researches must be effectively communicated amongst workers, from the lowest level of management to the highest level. Also qualified personnel should be employed for waste management especially into the government sector. There should be evaluation of workers, especially in the public sector to eliminate non-performing and redundant workers. This is to reduce the burden on the government and ensure effective waste management by staff.

Public education: One of the ways to ensure an effective waste management is through public education. As well noted, waste is a public good and waste management services provided to one of group of people does not diminish the benefit gained by other members of the community. Public education in waste management can be done in various ways, but one of the most efficient ways would be using the public media, especially the local radio stations, who have their programs in the local dialect. This would reach a bigger mass of the population. This should be done by the appropriate authorities and waste management experts. There can be phone-in sections, where people can bring in their ideas on how waste management can be done successfully. There should be constant education on the implications of improper waste management. During the education, more light should be thrown on the health and environmental cost of improper waste management. People should be made aware and understand the costs they have to pay if they do not manage their waste properly.

Research and Development, professional learning organization – learning alliances (National or regional waste management associations): It is important that research and academic institutions collaborate in their researches on waste. This can be done in the form of forum or conferences, so that ideas can be shared. It is necessary to build technical competence in cooperation between practitioners and research organizations.

4.1.3.5 Quantify and communicate benefits of change

Changing waste management from a system that is focused on getting waste away from the urban areas, with a large focus on transportation and landfilling or dumping waste, to an integrated waste management system where different waste streams are separated, treated and recycled requires that practices, organizations and habits are change. And there is always resistance to change. One important step in attaining willingness change is to quantify the benefits of the change. Some examples of such benefits are described below.

Reduced need for landfill space: Scarcity of land and the 'not in my backyard' notion are among the challenges of the waste management sector in terms of land availability for waste disposal. With proper waste management, some of the problems can be solved. Source sorting of waste should be encouraged and since a higher percentage of the wastes generated in these developing countries is organic waste, it can be put into productive use, such as organic fertilizer for agricultural activities. Also recyclable waste such as bottles can be separated from the waste. Contracts can be made with companies such as Coca-cola, where customers can receive an amount of money for return of cans. All these practices can help reduce the amount of waste, which ends up at the landfill site. This in effect will reduce the area of land needed for landfill activities.

Reduced pollution from landfills: landfills pollute the environment, especially non-engineered landfills. A waste management system which includes sorting of waste before it is sent to the final disposal site will help reduce emissions from the landfill site. The practice of co-disposing both hazardous and non-hazardous waste should be discouraged. This will prevent toxic substances from seeping into the soil, which will eventually pollute the ground water.
A special case of reduced pollution from landfill is the reduction of the greenhouse gas methane which is formed when organic matter is decomposed anaerobically. This environmental good can be transferred into economic funds through the Clean Development Mechanism (CDM) of the Kyoto Protocol which is further described in section 4.2.2.

Environmental and economic benefits of recycling: Recycling of non-degradable waste materials such as cans and bottles has both economic and environmental benefits. Bottles can be made into simple, but beautiful products such beads and sold on the market. Organic products such as compost can be made from organic waste and sold to farmers, which can help in reducing environmental pollution as well provision of employment. This is where the activities of the informal waste collectors should be recognized. The public should also be educated on the importance of the informal waste collectors. Their work should be recognized as very relevant: their activities provide livelihoods for many individuals; help in reducing environmental pollution; and can provide a service in keeping the neighborhoods clean. This encourages more people into the sector, which can then be formalized. A major step into this change of mindset is to avoid referring to these workers as 'scavengers', since it has a negative connotation. They can be referred to as 'reclaimers', tip pickers, or salvagers.

Reduced need for transport
By treating waste near the source of generation and recycling it within the urban areas, the need for transportation is reduced. This saves money directly by reducing the need for vehicles and fuel, and indirectly through reduced wear on roads and reduced air pollution.

Fig. 1. Piles of waste collected for recycling by the informal waste collectors (Appiah Boamah, 2011)

4.1.3.6 Occupational health

The working environment of waste workers is very crucial, because it combines both unhygienic conditions and risks of accidents (UN, Habitat, 2010).The health conditions of waste workers must be a priority for waste management companies, especially workers such as the drivers and waste collectors who are directly involved in the waste handling. Provision of protective clothing (proper working attire and raincoats) and materials (gloves, facial mask and working boots) are essential for this work. In Ghana, the waste workers within the private companies usually work from Mondays to Saturdays and even sometimes on Sundays. The workers therefore, have very little or no time to visit the hospital should the need arise. There should be work shifts to ensure that the workers get some breaks off their schedule to visit the hospital at least once a month for checkups. Fortunately, there has been the introduction of the National Health Insurance Scheme, where, all Ghanaians pay a small amount of money at the end of the year, enabling residents to obtain basic

healthcare services without paying money at the point of delivery of the service. This has replaced the cash and carry system that was previously in place and it covers 95% of all medical concerns. It has therefore made it easier for people to visit the hospital without having to pay cash. The private companies can register their workers and pay annually to ensure that the workers have easy access to the hospital.

Another important factor is the training of the waste workers in the proper usage of waste equipment, especially those within the formal waste management companies. This helps in the reduction of accidents that occur during their operations.
Again, workers should be made to understand the importance of using the protective clothing and materials given to them. Sometimes, the waste workers do not have a good understanding of why they should use the protective materials while others too feel uncomfortable using them, especially the face mask and gloves. There should be ongoing training programs on the use of protective equipment and materials for the workers in formal private waste management companies. Workers should also be made aware of the health risks associated with their work. They should understand the risk of getting waste related diseases such as bronchitis and asthma. Proper equipment and infrastructure should be made available to prevent the waste workers from getting these diseases. For the informal waste collection, formation of small organizations could be the first step before the training programs on how to use equipments and materials can be done for them.

4.2. Systems Suitable for Organic Waste Management

4.2.1 Technical solutions

Primary collection systems, treatment and recycling activities, installation, operation, maintenance

4.2.1.1 Waste Storage

Primary collection of Organic Waste should start first with separation of organic waste from the other types of waste. This will facilitate and secure the other steps required for the best management of organic waste. The recommended characteristics of an organic waste handling system are that it should be:

- Able to contain all the organic waste which is generated over a specific period (in addition to 30% of the storage volume as contingency space to act as a factor of safety in case of increase of the waste generation rates due to the natural (e.g. the beginning of months where most of people cash their salaries, or during weekends or, or during seasons such as the Christmas or feasts) or random factors (such as wedding parties, birthdays, elections).
- Made of durable material to withstand the weight, humidity and corrosiveness of the organic waste such as plastics, stainless steel, galvanized steel, zinc and so.
- Vermin-proof design to avoid animals, birds and flies or rodents.
- Compatible with the waste collection equipment, i.e. can be emptied easily either manually or mechanically/hydraulically into the waste collection facility (e.g. trucks).
- Located in cool, secure room, or aerated open area, where hot weather accelerates the decomposition of the organic waste which generates offensive odors.
- Cleaned and disinfected on a regular basis, while assuring the sanitary disposal of the wash water.

4.2.1.2 Waste Collection

The same criteria could be applied on the collection facilities of the organic waste, where:

- It should have enough volume to contain all the organic waste which is generated in specific places. Organic waste should be collected as soon as possible on a daily basis at least to avoid waste decomposition in the waste storage area.
- It should be made of durable material to withstand the weight, humidity and corrosiveness of the organic waste such as plastics, stainless steel, galvanized steel, zinc, etc.

- Tight design to avoid animals, birds, flies and rodents. It should also be equipped with a bottom hole connected to a small wastewater (leachate) collection tank, so it does not leak on streets during collection and transport.
- It should match with the waste storage facilities, i.e. it must be easy to manually or mechanically or hydraulically empty the waste storage containers or facilities.
- To be cleaned and disinfected on a regular basis while assuring the sanitary disposal of the wash water.

4.2.1.3 Waste Treatment

Following criteria could be applied on the treatment facilities of the organic waste:

- It should have sufficient capacity, even for peak occasions. Organic waste should be treated as soon as possible (on a daily base at least) to avoid waste decomposition in the waste treatment area.
- It should be made of durable material to withstand the weight, humidity and corrosiveness of the organic waste such as plastics, stainless steel, galvanized steel and zinc.
- Waste treatment includes volume reduction by cutting, or baling (especially for garden and arm wastes which is not applicable for household organic residues), drying if relevant for specific purposes, cooking or applying chemical treatment (e.g. adding some chemicals such as ammonia to make it edible for animals as animal fodder). These processes must be carefully calculated, prepared and implemented otherwise they would have a negative impact on the treated organic waste and the environment
- The facilities that have been used for treating organic waste have to be cleaned and disinfected on a regular base while assuring the sanitary disposal of the wash water.
- Treatment facilities of organic waste should be close to or within the borders of the final disposal area, where the residuals of the waste treatment could easily and cost effectively be disposed of there.

4.2.1.4 Waste Recycling

The same criteria could be applied for the recycling facilities for organic waste, where:

- Waste recycling facilities include composting, preparation of animal fodder, fuel (pellets/briquettes of refuse derived fuel (RDF)), construction materials and charcoal.
- Facilities should have sufficient capacity. Organic waste should be treated as soon as possible (on a daily base at least) to avoid improper decomposition of organic waste in the waste recycling area.
- Plant and equipment should be made of durable material to withstand the weight, humidity and corrosiveness of the organic waste such as plastics, stainless steel, galvanized steel, or zinc.
- The facilities that have been used for recycling organic waste have to be cleaned and on a regular basis.
- Recycling facilities for organic waste should be close to or within the borders of the final disposal area, where the residuals of the waste recycling can easily and cost effectively be disposed of there.

An example of one of the recycling facilities for organic and non-organic waste is shown in the satellite image in Figure 2 below, the May-15 Facility in the south of Cairo. It is a large-scale sorting and composting facility. For the marketing of the compost, quality control is of utmost importance for pricing and marketing. In the case of Egypt, it is possible to certify organic compost from a dedicated certification authority, the Central Lab for Organic Agriculture (CLOA) in the Agricultural Research Center (ARC) of Egypt. Sorting-at-source is not common practice in Egypt yet, but in time the introduction of this practice would significantly improve the quality of the compost and thereby improve its market price and the feasibility of the project.

Fig. 2 Centralized Composting Site in South of Cairo, visible wind-rows of compost

It must be noted that in rural areas, it is more common to utilize organic waste for animal feed, while in dense urban communities; centralized composting is a recommended option which has proved to be successful in several governorates in Egypt. It is, however, only successful in locations where the population density and organic waste fraction are sufficiently large. An initial baseline investigation must therefore be conducted before planning for compost sites.

4.2.2 Institutional requirements

This chapter describes institutional and other non-technical aspects specific for organic waste management. Most of the text is based on knowledge about composting, since that is the most widely researched and implemented technology. However, the text is expected to be relevant also for other types of organic waste recycling, such as use as animal feed, anaerobic digestion, fuel briquette making.

4.2.2.1 Marketing and Quality control

Quality control of the product is important, in order to build trust in the market. That can be done either informally (by established relations between seller and buyers), through government, or through voluntary formal institutions e.g. by a third party through certification. A recommendation is to facilitate marketing of products (organic compost, digestate, or animal feed) with non-bureaucratic and simple quality control procedures/guidelines. This is needed to add value of the product to encourage recycling and recovery and to facilitate formalizing the industry.
A market strategy for making the best use of the compost (or equivalent) is needed. Essential background information for a marketing strategy includes understanding the needs and willingness to pay of potential customers, and knowing the competitors, the quality and prices of their products. A marketing strategy should cover the 4 Ps:

- Product : Relates to features, benefits, quality, packaging, presentation but also service and abstract messages such as image or principles
- Price: Is dependent on the customers' financial circumstances, demand for compost and the prices of competing market products. However, it is also determined by production costs and expected profit margin.
- Place: Can be regarded as a link between the product and potential customers.
- Promotion: Supports and influences the perceptions and judgments of potential customers to ensure the sale of the product.

More information and practical guidelines on compost marketing can be found in Rothenberger et al. (2006). In Bangladesh, a market for compost from urban waste has been developed through successful cooperation with a distributor of mineral fertilizer. In that way the compost producer got access to an existing distribution network and a retailer with established relations with agricultural customers.

4.2.2.2 Funding

In most places, both in developed and developing countries, the revenue from selling compost is not enough to cover all costs of treatment and primary collection, but it can cover part of the costs. Other financing is also necessary, for example waste collection fees (Cofie et al., 2009, Sundberg et al., 2006).
Organic waste is a harsh and corrosive material that negatively effects mechanical equipment. It is therefore essential that funding for maintenance is included in the financing of any treatment facility.
The Clean Development Mechanism (CDM) is a mechanism under the Kyoto protocol aiming at transferring technology for reduction of greenhouse gas emissions from developed to developing countries. Organizations in developed countries pay for the technical installations and receive Certified Emission Reductions (CERs), commonly known as carbon credits, in return. Investments in technology reducing methane from waste landfills and waste dumps are often cost effective, and many CDM projects financing landfill gas recovery, waste incineration, composting and anaerobic digestion have been established worldwide. So far, there are only a few examples of successful CDM projects In Africa, but the number is increasing. CDM is an opportunity for funding that should be investigated for any large scale project on improving the management of the organic fraction of municipal waste, which includes greenhouse gas emission reductions through methane avoidance or through energy recovery to replace fossil fuels. Energy recovery on its own may also provide extra revenue or cost savings (Friedrich and Trios, 2011; Boström, 2010). It must be noted, that the portion of energy recovery from MSW that will be considered as a renewable source of energy is the organic part, i.e. oil-derived fractions, such as plastics, etc, should not be considered for carbon reduction projects when replacing fossil fuels since they are oil-derived. This is a common misconception in developing countries contemplating waste-to-energy technologies.

4.2.2.3 Coordination with other sectors

Energy sector
It may also be relevant to link with energy institutions, in the case of incineration or biogas production being considered, especially in the case of electricity production. If energy products are produced, energy market and policy stakeholders need to be involved.
Energy policies aiming at improved energy security and increased use of renewable fuel may already include policies to transform waste to energy through incineration or biogas production. This is an opportunity to improve both the waste management and energy security. However, combustion of organic matter for energy is not necessarily the best management option, even when assessed in terms of energy or greenhouse gas emission reduction. Factors to consider, apart from direct energy recovery, are (i) energy and greenhouse gases from production of mineral fertilizer, if compost or digestate can substitute fertilizers, (ii) energy needed to produce animal feed, if waste is originally used as animal feed, (iii) sequestration of carbon in soils when compost is applied in agriculture.

Agricultural sector
It is important to link waste management with agricultural institutions. Since organic waste can be used as animal feed or transformed into fertilizers, it is important to coordinate with agricultural professionals and organizations, especially stakeholders in urban agriculture (Hofny-Collins, 2006). The need for cooperation between the agricultural and waste sectors in organic waste recycling is relevant at all levels, from national policymaking down to compost use by individual farmers.
One important level that has importance for the success or failure of composting projects is the involvement of agricultural stakeholders in the marketing of compost. Potential sellers and users of the compost/fertilizer should be involved. These could include urban and peri-urban farmers, extension services, real-estate developers, nurseries, fertilizer wholesalers and retailers. See more on marketing in section 4.2.2.1 above.

Wastewater management sector
Sewage sludge management is a major sanitation challenge in many West African cities and co-treatment with sewage sludge may be beneficial technically as well as economically (Cofie et al., 2009).
In Ghana, solid waste and wastewater are both covered by the Environmental Sanitation Policy, and at the local level they are managed in the same municipal department. This is an advantage if

co-treatment of sewage sludge and solid waste is considered. In cases where solid waste and wastewater are managed by different units, coordination is needed if co-treatment is considered.

4.2.2.4 Knowledge management

Organic waste recycling has several specific challenges that require knowledge.

- Coordinating many stakeholders including households and other waste generators, private and municipal waste management professionals, agricultural stakeholders
- Financing the activities of each stakeholder
- Understanding the technical and microbial processes involved in anaerobic or aerobic (composting) digestion of organic waste:
    - Biological processes, microbial decomposition
    - Technical design
    - Quality control
- Agricultural reuse of organic waste products – management of nutrients and organic matter
- Successful organic waste management requires knowledge development both at the individual and organizational level. This requires organized institutions for building and disseminating knowledge on the issues listed above, and for addressing challenges that emerge during the implementation of ISWM. Examples of this are
- Project-based or long-term cooperation between research institutions, municipalities and private actors in waste management development projects
- An organization (National Waste Management Association) for cooperation between municipalities, which also provides links between researchers and practitioners

Cooperation between universities and the waste management sector involving students has special potential to increase the awareness of educated young people on the needs and opportunities in the waste management sector, as well as in affecting the status of waste workers and waste management in general in the society (Nzeabibe and Ajero, 2011).

4.3. Systems Suitable for Recycling and Recovery

4.3.1 Technical solutions

4.3.1.1 Primary Collection of solid waste

Considering the socio-economical situation of the target African countries, suitable primary waste collection models must be technologically tailored.

The primary issue with plastic waste is that there is a high level of contamination and also unprocessed plastic waste has a low value. As with other recycling initiatives, there is no money to be made in recycling (collecting) plastic unless it is taken at least part of the way through the beneficiation cycle.

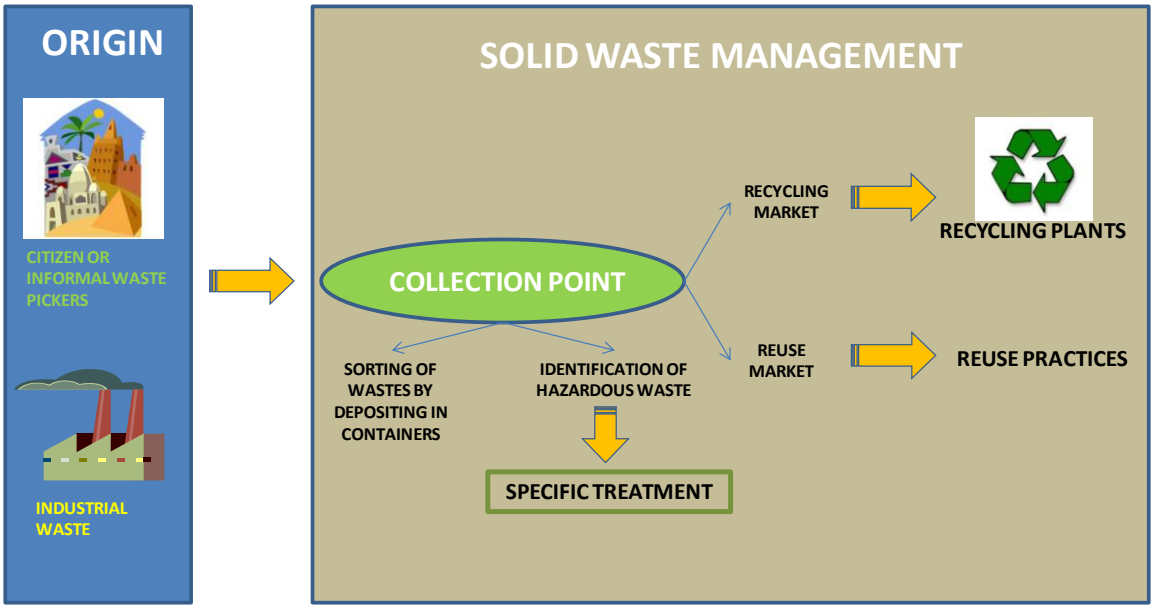


Fig. 3: Logistical scheme for a SWM system in target countries

In the Figure 3 a suitable logistical scheme for solid waste and recycling is proposed. Solid waste sources include house to house collection, regular collection from shops; hotels and industrial areas; current collection through the informal sector; and purchase from informal sector on the municipal dump. All of the solid waste should be transported to the closest collection point where waste sorting would be carried out in order to avoid waste mixtures as much as possible (which renders it difficult to recycle or treat) and also to sort all the existing hazardous wastes which would directed to specific treatments.

At the collection point, reuse and recycling markets would be developed at the interface between waste collectors (from informal or private sector) and reuse/recycling industry. Collection point management should be regulated by laws in order to avoid incorrect disposal, and prevent possible black markets.

4.3.1.2 Treatment and Recycling activities (Plastics)

The primary issues with plastic waste are that there is a high level of contamination and also unprocessed plastic waste has a low value. As with other recycling initiatives, there is no money to be made in collecting and recycling plastic unless it is taken at least part of the way through the beneficiation cycle.
Recycling plastics has many benefits; it contributes to energy savings and the reduction of greenhouse gas emissions. It also saves non-renewable sources like oil and gas. In addition, recycling provides livelihood for millions of people and families in developing countries, either in the form of formal employment or informal economic activities.
Target African countries should adapt low tech plastic recycling technologies as a start. Furthermore, there are some high tech plastic recycling technologies such as extrusion, pelletizing and injection which would give high added value to the recycled plastic final product.

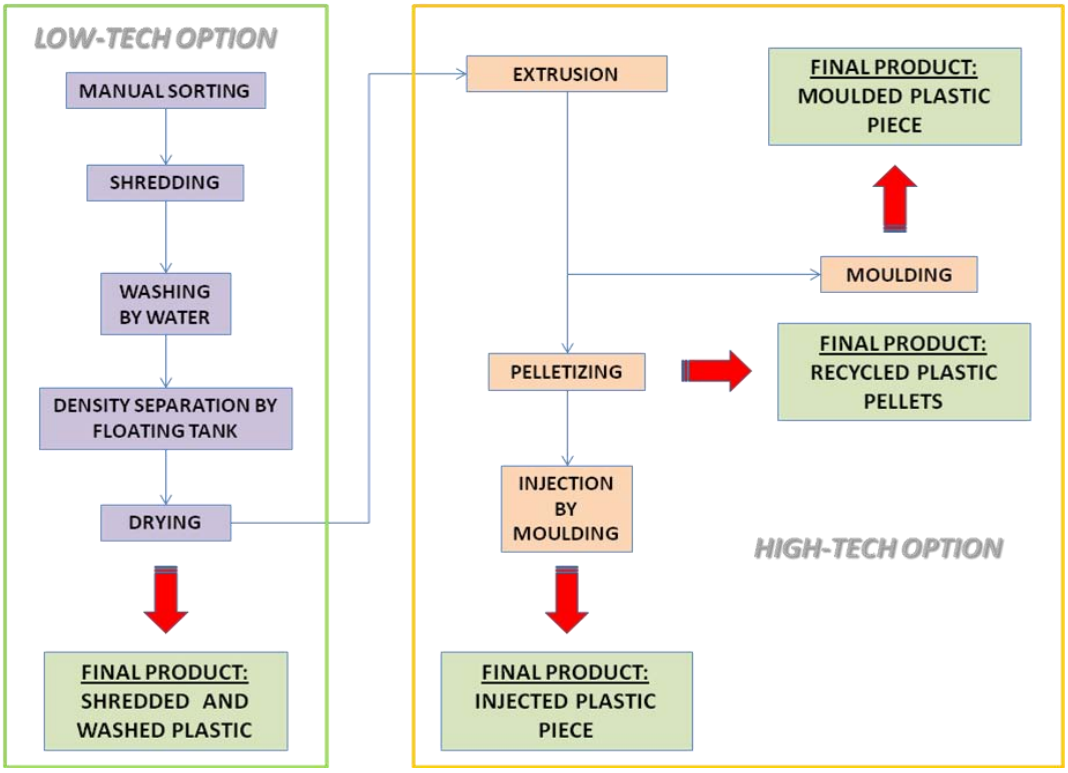


Fig. 4: Plastic recycling options for target African countries

1. Initial sorting and upgrading

Once the plastic has been collected, it needs to be sorted. The techniques used will depend on the scale of the operation and the type of waste collected, but at the simplest level will involve manual sorting of the plastic into the required groups. Sorting of plastics can be by polymer type (PE, PP, PET), by product (bottles, plastic sheeting) and by color.

2. Size reduction techniques

Size reduction is required for several reasons; to reduce larger plastic waste to a size manageable for small machines, to make the material denser for storage and transportation, or to produce a product which is suitable for further processing. There are several techniques commonly used for size reduction of plastics;

- Cutting (before the shredding)

  It is usually carried out for initial size reduction of large objects. It can be carried out with scissors, shears, saw, etc.

- Shredding

  It is suitable for smaller pieces. A typical shredder has a series of rotating blades driven by an electric motor, some form of grid for size grading and a collection bin. Materials are fed into the shredder via a hopper which is cited above the blade rotor. The product of shredding is a pile of coarse irregularly shaped plastic flakes which can then be further processed.

3. Washing

Plastic washing is carried out for the removal of heavy contamination from hard and soft plastics after shredding. The machines used to be fitted with a wash and rinse system to complete the cleaning process. The washing step, at the simplest level will involve hand washing.

4. Density separation by floating tank

Float sink tanks are designed to pre-wash and separate mixtures of plastics and contaminates using water as a medium to float out the fractions of plastics with specific gravity (e.g. separation of PE from PET)

5. Drying

Typically in film recycling plants after shredding the film is usually processed in float sink tanks to remove dirt and grit. The processed plastic can carry up to 60-70% water after washing.

After the washing process the plastic is fed into a drying machine such as a centrifuge or thermal dryer, and the water is removed by screw compaction. An easy and cheap but slow method could be open air drying of plastic; however this generally requires too much time.

6. Final Product

The final product would consist of shredded and washed plastic which has a good value in the market.

4.3.2 Institutional requirements

Solid waste management is a big challenge in all of the target African countries. Waste management requires the setting up of a number of discrete systems and solutions, from small scale education and recycling programs to the development of large scale technological solutions. Most of the individual systems set up to manage waste work at one level of the waste management hierarchy, which is commonly referred to as the three Rs – reduce, reuse, and recycle. The most favored systems and solutions are set up to tackle waste prevention and minimization, with less favorable solutions in place to deal with the reuse, recycling, recovery, and disposal of waste materials. Any comprehensive waste management solution needs to deal simultaneously with each of these levels, as well as create awareness within society about what is being done and how to improve it in the future.

Education and awareness is a very important aspect of global solid waste management. It is not enough to simply have solid waste management systems in place if the population is not aware of their existence. Without this awareness these systems will remain stagnant and will not evolve to meet the expectations of society. Educational programs on solid waste management need to be set up by both government and privately run organizations, to work in support of practical solid waste management systems. Along with educational programs, the development of new technologies such as transportation mechanisms and carrier rollers is another important aspect of solid waste management for Ghana, Nigeria, Ivory Coast and Senegal.

In terms of waste prevention and minimization, education is essential in promoting extended producer responsibility within the industrial sector. The further down the waste hierarchy that you travel however, the more practical and technological solutions need to be found. Energy recovery is a good example of how new and innovative technologies are transforming waste materials into a usable resource, such as in biomass production or in mass recycling programs. All of the African target countries must seek integrated SWM systems that are most suited to their needs and capacity.

4.4. Systems Suitable for E-waste Management

This section is based on the review above of best practice systems as well as a wider literature review of international e-waste management. It is divided into three sections: technical solutions, institutional requirements, and country-specific comments.

4.4.1 Technical solutions

4.4.1.1 Collection

In the global South, primary collection systems tend to be dominated by small waste collectors who obtain materials from landfills as well as businesses and households. Many times these collectors specialize in e-waste, but at landfills in South Africa e-waste is typically collected along with other kinds of recyclables. Trolleys and bicycles are often used to collect materials from households, either on waste collection days or by knocking on doors and asking for old materials.

South Africa has also established more formal systems of primary collection. Pilot projects have tried collecting e-waste at municipal waste sites, such as garden sites in Johannesburg. However,

this requires consumers to go to special locations and often the more valuable components are stolen before the contracted recycler picks up the materials.

What appears to be a better system is a drop-off at shops that sell electrical and/or electronic goods, where customers can drop off their old product when buying a new one. Some cell phone companies have started taking back old phones, and many computer and electronics shops, as well as shops that sell electrical goods (white goods like stoves and microwaves), take back e-waste. Reportedly, workers at these shops are sometimes given access to this material to supplement their wages and theft of the valuable parts is also reported. However, formal relationships between recyclers and these shops are being established to divert this e-waste into formal streams.

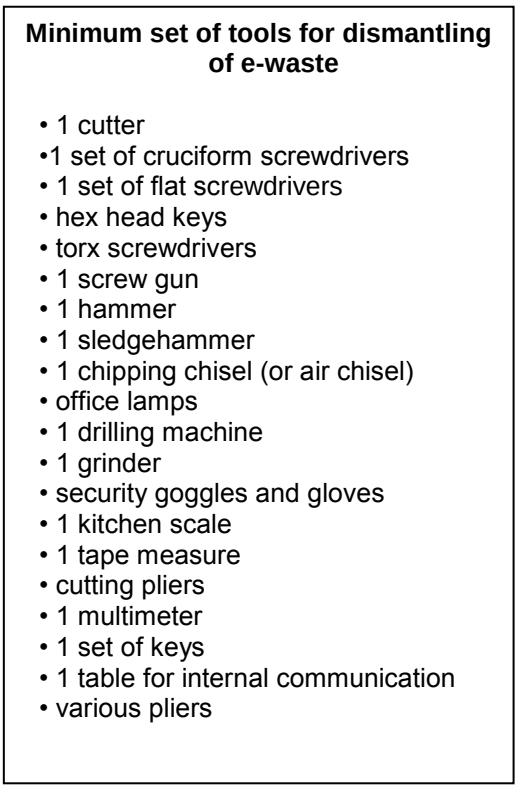


Fig. 5: Minimum set of tools for dismantling of e-waste

Many recyclers cold-call electronics and computer shops to see what is done with their e-waste. Building consistent relationships with businesses over time helps lower this administrative cost. While many consumers are willing to part with their e-waste without payment, some recyclers pay small amounts to the shops which are collecting the waste. Businesses also typically require some kind of incentive to release their old electronic and electrical goods. One Capetonian business, Just PCs, has developed an innovative way to avoid capital outlays for accessing e-waste: they facilitate the donation of a portion of the refurbished e-waste to social causes such as schools and NGOs.

In South Africa, waste electrical appliances (white goods) have been recycled as scrap metal for a long time. A growing concern has been raised particularly around electronic goods (like computers and cell phones) as well as some kinds of electrical items like some lighting equipment because of their hazardous content and the processes used to recycle them.

This whole system of primary collection may significantly change in the near future to follow a more structured model of collection. There are currently different models internationally, including individual and collective producer responsibility in which manufacturers are responsible for establishing and funding a collection system, or advanced recycling fees are paid that provide recyclers with a subsidy to help cover the cost of recycling. Which of these will work best remains to be seen, and South Africa has yet to decide on which model it will follow.

4.4.1.2 Recycling and Refurbishing

UNESCO's Entrepreneur's Guide to Computer Recycling provides a plan for a 300 m² storage room, a 200 m² courtyard and a 100 m² workshop which provides space for 10-15 workers. One South African business estimated needing around 30 m^2 per dismantler. UNESCO's suggested minimum set of tools for basic dismantling is listed in the box to the right.

The training of employees is an essential aspect of ensuring that the recycling/refurbishing is safe. Basic training should not take longer than four weeks but it takes up to three months to gain the necessary experience on the job. The salary for workers in South Africa is around $14/hour, with a slight difference in the hourly rate during and after training. Because most of the more hazardous components are well-contained, it is critical for worker and environmental safety to ensure that e-waste is dismantled in the right way. Basic safety gear such as gloves and eye glasses are essential.

In the global South, various treatment and recycling activities occur which are problematic for the environment e.g. the burning of cables and the use of acid baths. However, given the ecological costs of these activities, these practices should be avoided. Importantly, setting up profitable alternatives and enforcing regulations are both necessary to start changing practices, as detailed below.

Given the demand for job creation and the environmental benefits, manual dismantling of e-waste is the most suitable solution in the global South for the majority of steps. In South Africa, most small recyclers simply perform manual dismantling and separation of the e-waste and stop processing at this stage. Workers can process between 100 and 150 kg in an eight hour day. Cables and PC boards are typically sent to larger companies who shred and smelt the materials (separating the metals and plastic in cables is possible, but too time consuming to be economically viable). This division of labor can prove to be beneficial for the environment and economy as long as fair rates are paid to the smaller companies for the unprocessed materials.

In the recycling/refurbishing facilities, e-waste is separated into categories. These differ based on the purchaser of the materials, and it is important to know where the materials will go when deciding how to separate them. Hazardous wastes must be kept separately and labeled. It is essential to find a suitable solution for these; in South Africa, some CRTs are smelted, but most simply go to the hazardous waste site and businesses must pay for the disposal of these components. Plastics must be sorted according to the requirements of the collector. In Cape Town, one of the main uses of e-waste plastic is to make roof tiles.

The specific costs will vary, but a start-up budget should consider the following:

- Legal fees to establish business
- Transportation- vehicles such as trucks, trolley
- Furnishings such as workbenches and electricity
- Tools
- Running costs: Lease of premises
- Collection
- Employee wages
- Maintenance of any tools, vehicles
- Disposal of negative value components

Refurbished computers typically provide the greatest profit for recycling/refurbishing companies. E-waste businesses that focus just on recycling may require more financial assistance from manufacturers.

4.4.2 Institutional requirements

In order for the technical solutions described above to be adequately implemented and supported, wider institutional arrangements are also needed. A legislative framework is typically necessary but in itself is not sufficient for ensuring that suitable systems are chosen. There are several different scales of legislation: international, national, regional, and at the level of specific operations. Different kinds of regulations may be needed for e-waste because it contains more problematic materials, such as CRTs in computer screens (e.g. lead) and refrigerators (e.g. CFCs which are ozone depleting substances).

In many cases, legislation has proven ineffective because it is passed without support from those most impacted by the regulations, without ways of enforcing it, and without providing alternatives and assistance for e-waste businesses to meet the new requirements. For these reasons, it is important that broader governance issues are taken into account. In South Africa this has mainly taken the form of business associations, but there is a need to ensure that these organizations do more than just promote their own interests.

4.4.2.1 Legislation

In terms of international law, the Basel Convention and the Bamako Convention are important for e-waste. These laws ban the uncontrolled transboundary movement of hazardous waste such as e-waste from the global North to the global South. Despite their widespread adoption in West Africa, in practice there continues to be extensive import of e-waste. It is generally recognized that better checks in the global North, control at key harbors in West Africa and clearer definitions of what is "waste" and what are "second-hand" electronics are needed to stem this flow.

In addition to this international law, specific countries need to consider regulations enacting these international rules. Passing national laws banning the import of e-waste from the global North allows the state to enforce the ban.

Also at the national level, the government can regulate what can or cannot be landfilled. Banning the disposal of e-waste at landfills is a good way to improve the likelihood of it being recycling, however, this will only work if adequate options are present for recycling or it may lead to dumping of e-waste in inappropriate places.

Additionally, government can pass standards which will apply to the management of e-waste. Such standards need to take local context into consideration. The European Union has adopted standards for e-waste processing, and the e-waste Association of South Africa has also developed technical standards, but there may be a need to adapt these. At present there are no laws which specifically mention e-waste in South Africa, but the draft National Waste Management Strategy (NWMS) is expected to be finalized soon, and is likely to require Industry Waste Management Plans in which industry decides how it will respond to the existing e-waste challenge.

4.4.2.2 Governance

Given the limitations of government in establishing enforcing regulations, businesses can establish participatory governance systems as a way to work together to improve e-waste management. In order to get the input and support of manufacturers and recyclers, a participatory body can provide a forum for dialogue. This body should be a non-profit organization which is funded by contributions from industry. In South Africa, this took the form of the e-waste Association of South Africa (eWASA). The association is expected to be run by a group of manufacturers, although in practice the chairman has played a strong role in providing direction and making decisions.

The organization and principles of the guiding body are important to consider. A body which is run by manufacturers will likely prioritize the interests of manufacturers; while a body run by recyclers will likely prioritize recyclers. Thus, cooperation and compromise in the association are essential. Small collectors must be brought into the system from an early stage to prevent the establishment of dual systems or structures that put these small collectors out of work.

A key task of this association is to establish a national system which helps subsidize e-waste recycling and improve standards as described above. Such an association can also provide public

education, information and skills sharing. As a non-profit body, information should be shared widely and training provided.

There will be costs associated with this, for example, some information provided only to members of the association to ensure participation (and paying of dues). However, the costs of the operation need to be equitably distributed. According to the principles of "polluter pays" and "extended producer responsibility", large manufacturers who operate with larger profits and greater ability to predict future incomes should bear the major costs.

Should a non-profit organization like eWASA be established in West African countries, there is a need for it to remain independent. If those running the organization develop business interests that compromise this independence, the legitimacy of the system will be called into question. Any such association needs champions to promote the interests of the association, but these need to be separate from the interests of particular businesses.

Comparing National E-Waste Management Systems

In South Africa, there are two key organizations proposing slightly different variations of a national system. eWASA has existed since 2008, and their version is described in the current National Waste Management Strategy (DEA 2010). This system includes the payment of an advanced recycling fee which will be managed by eWASA. Different recyclers can then compete for tenders to process the waste collected through eWASA's system.

This system is similar to that used in Switzerland, and has been reported to be very effective, although more expensive than many other systems. The eWASA system was intended to be developed through consultation with stakeholders, but many within the organization - particularly manufacturers - feel that their perspectives were not adequately considered. The consequence of this is that a group of manufacturers has formed a separate ITA EPR (Extended Producer Responsibility) Group.

The ITA EPR Group believes that competition among different collection and processing systems is essential to keeping prices low. This principle underlies their system. While the details of the system have yet to be determined and/or made public, it is likely that in this system, different manufacturers will be responsible for managing set amounts of e-waste. They can collect this directly, or in cooperation with other manufacturers. They will then find collection, recycling, and refurbishing companies and engage directly with them, providing whatever, if any, financial assistance is required.

There are many similarities between the systems, in that both include producer responsibility, a national collection system and competition. However, in the eWASA system, eWASA determines the financial responsibility of the manufactures (and can include costs for public education, the development of standards, etc.) while in the ITA EPR Group system, the price is determined by whoever can provide a service at the lowest cost. Arguably, the single system provided by eWASA is less confusing to consumers, although the ITA EPR system may in the end only use a single collection system as well. Competition occurs in both systems, but at different points in the process.

One key difference between the two systems is that eWASA provides the possibility for a reasonably neutral body which has participation from manufacturers as well as recyclers, environmental NGOs, ICT NGOs, and consultants. While its meetings are not open, there is a degree of transparency and because of the dues paid, the association is responsible to its members. The ITA EPR Group, however, consists thus far only of manufacturers. While recyclers are to be consulted, they do not have a formal role within the organization.

The role of small recyclers and refurbishers is unclear in both systems: centralization of decision-making in both systems makes it more likely that large recyclers and refurbishers will be favored since they will be able to manage larger volumes of e-waste. Informal collectors will still be able to collect e-waste, but the volume which goes through informal channels would be significantly reduced by the introduction of a new system.

4.4.2.3 Spreading Costs and Limiting Vulnerability

In order to establish and maintain any e-waste management system, the costs and benefits of the system need to be distributed among different stakeholders. One concern is the need for all kinds of manufacturers to participate, and to appropriately distribute costs. Some kinds of e-waste cost much more to manage (e.g. monitors with CRTs), while others (e.g. stoves which can be turned into scrap metal) are already profitable. It may or may not make sense to include all these different types of e-waste in one system. For example, the lighting industry in South Africa is developing their own e-waste management system, and this may prove more effective than including it with other types of e-waste because of the special requirements for its management. Regardless of whether different streams of e-waste are combined or separated, it is important to spread the costs of recycling equitably.

Recycling businesses are typically very interdependent, and the success or failure of each is interrelated. A single, small dismantling plant cannot succeed in isolation because it needs upstream suppliers of material and downstream businesses to purchase the separated material. Thus, there is a need to create a viable, local recycling economy to support the e-waste recycling and refurbishing industry. This may include appropriate, funded hazardous waste facilities to take the hazardous components.

There is also a need for businesses that purchases metals and plastic. In Cape Town, e-waste plastic is typically sold to a manufacturer of roof tiles. However, having a single local purchaser like this can limit the operations. The local plastics recyclers stopped purchasing (or even taking) plastic at one point. The recyclers were then stuck with large volumes of plastics which they could not find a use for. Thus, there is a need for upstream and downstream suppliers, and ideally a variety of options so that the viability of the whole recycling chain is not threatened if a single business fails or stops accepting material.

Having a single, unregulated business in any particular sector should also be avoided because it may allow for monopoly pricing. For example, in South Africa there is currently only one purchaser of PC boards. Some small companies could join together and get a better price through exporting to Europe, but this in turn means shipping resources, profits and jobs overseas. There is a need for fair prices and also the sharing of technologies to enable local industry to compete with global prices.

4.5. Requirements for accommodating the informal SWM sector

4.5.1 The informal sector

The informal sector comprises the unregistered, uncontrolled, unregulated activities, individual and family enterprises, small-scale and low income-intensive technologies. The sector exists and operates because of market forces or socio-economic factors in low income countries. It may occur at several stages in solid waste management starting from household or business level, where waste materials are accumulated and are either sold, disposed of at the communal storage areas, or dumpsite.

A significant factor in the waste management sector of developing economies is the presence of extensive informal sector activities either in the form of recycling enterprises of itinerant waste buyers and dealers or through self-employed or municipal sweepers collecting waste for an agreed payment from a household. The activities of NGOs and CBOs in waste collection and disposal are also considered informal. It is generally believed that the informal sector is well able to perform basic waste collection services at low cost because labor is cheap and because they are able to communicate directly with people being served by negotiation. Their sense of local conditions and people make them more sensitive to changes, demands and expectations from the public, hence they tend to deliver effective services.

4.5.2 Activities of the informal sector

4.5.2.1 Primary Collection

Ghana's informal sector activity in primary collection usually uses the push/pull cart system, tricycles, wheel barrows and tool level equipment capacity. They normally operate in low income

areas, on landfills and areas in the urban centers where population density is high. They complement the activities of the public or formal private sector collectors. They collect municipal solid waste for a fee, collecting separated solid waste types such as plastics, metals, papers and other recyclables, but not organics (in case of Ghana). One advantage is their ability to collect or recover material from areas that are not easily accessible to collection vehicles due to the bad condition of roads.

Households make verbal agreements with the collectors or sweepers, or the collectors make agreement with each other not to compete so they share operational areas among themselves. Sometimes, the right to service an area is bought or exchanged among sweepers or collectors.

Advantages of this system are:

- It includes low overhead costs so it directly benefits the poorest of poor.
- It is flexible

Disadvantages Includes:

- This system does not operate successfully where there is no reserved area such as a market or where users are not able to pay.
- Poor regulation of the service
- Poor basic health and safety standards.
- They find it difficult to formalize because of their inability to pay local tax or the equivalent.

4.5.2.2 Recycling

Informal sector recycling of domestic waste can be divided into two broad categories:

- Waste picking at disposal sites, streets, communal bins, etc
- Itinerant waste/material buying from the households.

The largest informal recycling groups are made up of itinerant buyers and landfill tip pickers/salvagers. The itinerant waste buyers receive separated valuable waste components (such as plastics, metals cans, ferrous etc) from households measured by weight. The itinerant buyers move along the street with pushcart, donkey cart or bicycles or on foot with polysacks to collect or buy the separated items, or they buy from an established base.

4.5.3 Integrating the informal and formal sectors

The informal sector plays an important role in bridging the gaps in the SWM sector in low income areas by providing services which are not provided by the formal sector. The informal sector therefore forms an integral part of the SWM and must be considered while planning for future systems of integrated waste management; since

- They bridge up gaps left in the low income areas
- Income from this sector is a survival strategy for a large number of the urban poor.
- It creates employment for the neglected and vulnerable groups in the society.
- It acts as a buffer against poverty for groups who do not have social security.
- They recycle or recover a considerable portion of the waste thus diverting it away from the landfill.

4.5.3.1 Privatization and the informal sector

Privatization and zoning of areas of waste collection for the formal private sector has posed threat and jeopardized the work of the informal workers. They are excluded from operating a house-to-house collection system in the zones allotted to the formal sectors. This implies that the community waste solid waste collection scheme which exists for the urban poor is also threatened and the source of livelihood of the informal sector suffers. In addition, the formal private sector provides services at a relatively higher cost and this directly affects the low income areas if not subsidized.

4.5.3.2 Constraints for integrating the formal and informal sectors in SWM

Integrating both the formal and the informal sectors in SWM has become a difficult task to consider. A recent interview conducted with house to house waste collectors, pickers, scrap

dealers and scavengers in the City of Accra on how ready they are to join the formal sector and have a regularized operational structure, revealed that these workers are not ready to do this and would still want to be on their own. Reasons given include:

- Some of the waste collectors or pickers are perceived by the community as thieves, unruly and unreliable hence suspicious of genuine work. This therefore does not make portion of the society accept the work of the informal sector.
- Some waste pickers/collectors are reluctant to be integrated into the activities of the formal sector and even to be organized because they are of the view that they may earn less than their current income since elements such as taxes could be introduced when integrated.
- Others claim the salary been paid by the formal sector is not sufficient and are not quite sure if they would be put on the same scale or what remuneration they would receive.
- Some feel that they would be controlled by the formal sector when integrated and will no longer enjoy the existing flexibility in their work.

Thus any plan of integration ought to address these issues and also give reassurance to them that they would not be left worse off, but would rather benefit from their work being more efficient and acceptable.

4.5.3.3 Recommendation for the integration

In view of the trend towards privatization of waste collection in many developing countries, involving the informal sector is seen as a good option to increase collection efficiency and rates. To include the informal sector the following points are important:

- The formal sector or the local authorities should identify areas where they have difficulty in providing collection service for the informal sector to fill up, especially inaccessible routes in slums and other poor communities, with their supervision.
- There should be community backing and endorsement of informal activities. Negative perceptions and suspicions should be well managed through public education.
- Local municipalities should give the informal sector political backing.
- There should be investment in the informal sector in terms of equipment such as buying of carts, tricycles, wheel barrow, etc. Donor agencies, governmental agencies, NGOs, formal private companies are encouraged to go into the aid of these informal sector workers to invest in equipment and other facilities required by the pickers/collectors.
- National programmes on employment should identify the informal waste management sector, absorb them and coordinate their activities.
- There should be an association which will include all the streams in the informal waste management sector to appeal to the Central Government for recognition, allocation of operational areas and other assistance deemed best for progress of work.
- There should be well established centers where pickers, itinerant buyers, recyclers, and other middlemen to industries, meet for business
- Buy-back centers should be established in various parts of the cities for waste pickers to sell their products.
- The waste collector must be provided with temporary storage facilities such as communal containers, transfer stations, etc where they would pay a minimal fee for dumping and management of the facility, to avoid illegal dumping often engaged in by these informal waste collectors.

4.6. Integrated SWM systems in target countries

While economic considerations remain the key driver for SWM decisions, social or environmental considerations are often totally over-looked and therefore result in unsustainable systems being

selected. Triple bottom-line evaluation principles must be applied in the choice of any IWMS which must also show integration across the differ spheres of government and across different sectors in society. These are discussed below.

4.6.1 Social considerations

These include governance and institutional arrangements, organisational strategies and structure, participatory principles and the capacity of people within the system to make it work.

4.6.1.1 Ensure Stakeholder Inclusivity

Irrespective of European or African context waste management affects everyone in every day's life therefore from the outset all groups of society as well as their respective needs and agendas have to be included in a truly comprehensive Integrated Waste Management Plan. Community which reflects and ranks the key waste management issues at hand.

Civic groups and NGOs and other non profit organizations have to be involved to ensure that broad public interest issues are sufficiently represented. The business sector which is often a key generator of waste must be involved as well as households (both formal and informal) where in Africa the day to day waste management is mostly carried out by women and children. Both formal and informal collectors and recyclers are crucial stakeholders as well. For poor urban dwellers their involvement in waste management activities often contributes their basic income generation and therefore they should not be left out of the planning or implementation of waste activities (e.g. with the City appointing commercial collectors of recyclables in their working and living areas). Underprivileged groups and minorities often pose direct challenges to a system imposed by "out of touch" government bodies unable or unwilling to consult the public sufficiently to establish grass-roots based needs. Communities that are not involved in planning and that do not benefit from any chosen waste management system will fight, undermine, boycott or even vandalise it wherever an opportunity arises. This in turn will mean the need for massive law enforcement which is typically unachievable in African countries where even the most basic waste legislation is often not in place, or, if in place, there are not enough financial and human resources to enforce it.

It is very important to see the pivotal role the informal sector plays in the entire system for example in reaching national recycling targets. From another perspective it is a strategy to fight poverty and to grow much needed niches for entrepreneurship and job creation from waste beneficiation programmes.

4.6.1.2 Long-term Planning Requirements

The development and implementation of an Integrated Waste Management Plan is neither a once-off nor a permanent quick-fix solution. While politicians would like to see that everyone receives exactly the same municipal treatment in the name of "service equity[8]" it is inefficient to do so since different stakeholders have entirely different waste management needs. The IWMP needs to be flexible enough to address future waste management challenges such as a changing waste stream mix as a direct result of increased disposable income on household level while making sure policy and day to day waste management planners are in touch with best practice technologies and up-to-date integrated waste management concepts.

In Europe, waste management has been transformed over the last few decades from a system based on landfilling of mixed waste (including organics), to large quantities being source-separated, composted and recycled. This process is highly dependent on the willingness of all key stakeholders to change and adapt: change management has to include every stakeholder from household level right up to the industrial level. It is inevitable that this process takes time. Long-term plans are therefore needed, which set step-wise targets, priorities and clearly identify problems that need to be solved in the short, medium and long-term. System analytical research

[8] Obviously basic service level agreements and performance such as a once a week removal of waste for all formal household waste and regular skip removal in informal areas needs to be adhered to but when it comes to introducing any form of a waste beneficiation/minimisation programmes (such as a household collection of recyclables) the needs and resulting potential efficiencies differ vastly.

as discussed in section 3.2.2.4 can be helpful in uncovering financial and environmental costs and pointing out potential benefits.

4.6.1.3 Clear division of responsibilities

The development of any integrated waste management system, which includes policies as well as day-to-day planning, must be based on a clear separation of powers (legislative, judicial, executive). With poverty being such an enormous issue, African countries have a notoriously poor track record concerning issues such a bribery and nepotism. All too often a political preference for a waste treatment system has little to do with its performance, efficiency or the amount positive development it brings the public at large but more with the fact that a powerful politician is an esteemed board or management committee member of a company that commercially trades in this aforesaid type of technology.

Also policy makers should not be policy executors in general as this poses a serious threat to the core democratic principle of a country and its "private-agenda-free" governance.

Government roles in the three spheres (national, regional/state and local/municipal) need to be clearly separated too. While national policy should form the overarching guidance and set the general tone it should be up to provinces and municipalities to practically deliver waste services to the public and to develop by-laws as the framework for making efficient municipal service delivery happen. Also it is important that the by-laws are never in conflict with any acts or policy developed in higher governmental spheres. Metaphorically speaking national legal guidance should provide the "skeleton framework for core deliverables, timelines and objectives" filled in with the "meat" by the provincial and local authorities on how practically to achieve national policy principles (e.g. extended producer responsibility) and meet waste diversion and prevention targets.

The local policies need to spell out clearly the roles and responsibilities of all stakeholders e.g. for waste collectors, industrial and commercial waste generators as well as for formal and informal households.

4.6.1.4 Systemic aspects that are built on "economies of scale" and fully reflect the country's particular local socio-economic context

Systems for source-separation of recyclables or organics must fit the local context, give room for developing the system gradually, and ensure that infrastructural planning is efficient and effective by fitting the "economies of scale".

Low-cost technologies and labour-intensive systems of waste management should be considered as priorities in developing countries. Such systems are often more cost-efficient than the capital-intensive systems anyway and result in more recycling and recovery while providing job opportunities (GTZ, 2005). It is also important to ensure maximum acceptance from stakeholders and most beneficiaries of any planned system.

4.6.1.5 Knowledge management, information and communication

Continuous knowledge management, build up of new information (ideally as part of an NGO or even a government website that can act as a clearing-house) and subsequent communication are vital to ensure a country stays abreast of the latest policy developments and practical planning around integrated waste management systems.

Continuous staff training at all government spheres is as important as ensuring that governing politicians stay in touch with the practical challenges of waste management and the opportunities it can provide (e.g. job creation in the informal sector). Municipal budgets are set by political decisions so a waste department has to ensure that, in the political eye, waste management deserves the attention and funding it requires being pro-active and integrated. If not, it will remain simply in "crisis management" mode.

The general public needs to be educated about waste management issues and just communicating a message to recycle more and not to litter does not fit the educational brief anymore. The public is a key waste generator next to industry, and so every attempt must be made to create awareness about the intrinsic link of overconsumption and unnecessary waste generation (see also educational videos e.g. www.storyofstuff.com. Such a message can be conveyed with great

success in schools, businesses and public viewing houses to drive this point home. Quantifying and communicating the benefits of change lie at the heart of ensuring long-term commitment for waste management programmes.

To stay abreast of state of the art waste management planning and execution it is necessary to build technical competence in cooperation with local research organizations. Research and Development need to be undertaken locally to create local waste solutions while professional learning organizations such as national or regional waste management associations need to form powerful learning alliances and "think-tanks".

4.6.2 Environmental considerations

External environmental and health costs that will be reduced by improved waste management:

- Reduced need for landfill space
- Reduced pollution from landfills
- Environmental and economic benefits of recycling

4.6.3 Technical considerations for Integrated SWM systems in target countries

The huge socio-economic disparity between rural and urban areas in target countries makes it necessary to adopt a different approach to Integrated Solid Waste Management Systems. Whereas expensive technologies and centralised systems may be deployed in the urban areas, the same cannot be said of rural areas. Decentralised systems that are less expensive to install, manage and maintain will be more appropriate for such areas. The principle of the 3 Rs – Reduce, Re-use and Recycle – should be the basis of any integrated solid waste management system for the target countries, even though the concept of zero waste may not be realised any time soon. There will always be the need for a final disposal site for some waste streams although the emphasis should not be on waste disposal to the detriment of the 3 Rs.

4.6.3.1 Reduction of waste

Population increase is most likely to increase the volume of waste generated. In recent times the unwillingness of land owners to release land for constructing landfills and scarcity of dumping sites have been a cause for concern. Even when there are enough waste disposal sites, the question of sustainability gives room for alternative thinking. Waste reduction is indeed a must and an important key to any successful ISWM systems in West African countries.

In an effort to reduce waste generated, the Government of Ghana has made the polluter pays principle its pivotal policy. Though good, it has not led to any significant decrease in the quantity of waste generated. This is due to the fact that the polluter pays principle is interpreted to mean people must pay for the waste they generate. The policy should be extended to punish people who generate more than average waste quantities. Such punitive measures are likely to trigger a significant waste reduction. To do this, waste collectors must be mandated to weigh waste collected from each household before removing it. A monthly bill is then issued based on the kilograms of waste generated in a month rather than the monthly flat rate that is presently being charged irrespective of the quantity of waste generated.

In rural areas, where households pay as they dump their waste in skip containers, the same can be applied. Waste brought for dumping must be weighed by attendants of waste collection firms and the appropriate fees charged before they are dumped. Before these policies can be carried out, strong legislation and by laws preventing people from indiscriminately dumping waste must be in place. The concept of sanitary inspectors must be revived and strengthened to check those who will flout these rules.

Education is the key if these systems and government policies are to work. Government through Non Governmental Organisations and Community Based Organisations will have to embark on massive education to inform people.

Controlling corporate bodies that generate industrial waste is much easier. Strong legislation limiting them to some agreed quantity of waste should be in place. No such policy is in place at the moment so companies who can recycle even part of their waste or re-use some of it are not

obliged to do so especially when it is a more expensive option. An area where government can make significant progress in waste reduction is to enact and enforce legislation that will force or encourage industries to reduce their packaging material. This can be extended to importers who bring goods from other countries to sell. All goods whose packing exceeds a percentage of the product should be surcharged to discourage their importation into the country. Other measures such as an ongoing reward system for individuals and corporate bodies that consistently reduce their waste should also be put in place.

4.6.3.2 Re-use

Traditionally Ghanaians are used to re-using packaging materials and containers. Empty bottles are washed and used to store foodstuffs like pepper sauce and jam. A large unregulated informal sector goes around collecting empty bottles and washing them for resale to hospitals for dispensing liquid drugs. Since this is an unregulated business it is very difficult to quantify it. Empty paper cartons are used in homes to store goods. Large empty plastic drums are also re-used to store water in homes. On a holistic approach, government legislation should encourage the use of reusable packaging units or a take back scheme for packaging units by industries that produce them. Companies that do not have any mechanism of collecting and re-using their packaging materials should be surcharged.

4.6.3.3 Recycle and resource recovery

ISWM systems must take care of recycling and resource recovery in cases where reduction has been achieved and re-use is not possible, yet the waste can be turned into something that is useful. Organic waste for instance can be composted and used as a soil additive to improve the yield of food crops. In prescribing composting, note must be taken of the many failed composting initiatives in the past. Lessons learned include huge initial capital investment due to choice of technology, low patronage by local farmers, high cost of final compost and quality assurance just to mention a few. Large centralised compost plants may be good for urban areas only after the following have been taken care of:

- proximity to waste generation centres or access route to site devoid of heavy vehicular traffic
- low cost technology guaranteeing product quality
- proximity to demand centres
- clearly identified market for products
- Good financial plan.

In the absence of these any such large scale centralised compost project in urban areas is likely to fail just as the earlier ones failed.

Waste generated in rural areas is predominately organic. Aside from feeding their livestock with some of the organic waste, the remaining organic wastes end up at dump sites. Most rural dwellers have backyard farms. Government can capitalise on this by training individuals through the district assemblies to set up their own low cost, decentralised compost plant in their homes. Compost produced would be used on their backyard farms to increase the yield of their crops which they can sell to generate additional income. This concept can also be introduced in urban areas where affluent households have gardens and or small backyard farms. When this is carried out effectively, waste quantities requiring collection will be reduced significantly.

To date Ghana is yet to implement sorting at source. This makes plastic waste recycling so difficult. Plastic recycling companies complain of additional cost incurred in cleaning the plastic waste before recycling it. In the absence of sorting waste at source, government can grant subsidies in the form of a tax rebate to companies that prove that they are recycling plastic waste. This can be sustained by putting additional levies on plastic products for consumers to pay.

4.6.3.4 Incineration

Incineration of waste can be carried to either reduce the waste generated or recover energy for other purposes. A few pilot incinerators for waste reduction have been installed in the past but

none is presently being used for municipal waste. The few that are in operation are used to incinerate medical waste because of their health implications. Decentralised waste incineration to recover energy can be one of the ways of dealing with the problem of low energy access in rural areas. Decentralised waste incinerators can be used to set up mini isolated grid systems when the unit is used to generate electricity. In recommending incineration, care must be taken because of the high moisture content of MSW in West African countries. In one study, the moisture content of fresh MSW was estimated to be around 60%. This is very high and will make the energy recovered smaller since much of the energy will be used to evaporate the water.

Large scale centralised incinerator systems using plasma technology have been proposed in the past. The huge financial outlay, high moisture content of the waste and low electricity tariffs in the country must have put investors off. Any such large scale centralised system must come along with a cheap technology and be able to negotiate for better tariffs if the unit will be used to generate electricity.

4.6.3.5 Landfill

So long as the concept of zero waste remains a theory rather than a reality, landfills will be needed in any integrated waste management system. Though this should be the last option, as an example, landfill is the first option in Ghana's Environmental Policy, 2010. Engineered landfills are expensive to build; nevertheless there is a need to have them. Waste that cannot be reused and or recycled will have to be dumped somewhere. The practice of dumping them anywhere in open fields cannot and should not be allowed to continue. Even though the Government of Ghana, for example, has been keen on building more engineered landfills, land acquisition has been a major problem. A classic case is Accra where the government secured a World Bank loan to construct an engineered landfill at Kwabenya, a suburb of Accra. The residents objected to the idea and have opposed it since 2006. To date no actual work has taken place. Waste collected in the Accra Metropolis is currently being dumped in open fields and abandoned quarry sites.

4.6.4 Financing principles that should form part of an IWMS

There are two types of financial instruments upon which a government can build its IWMS finance – either on incentives or on disincentives and penalties also known as the "carrot and stick approach". Some of the most powerful economic instruments include:

- Implementing the polluter pays principle
- Fees for waste collection waste type and/or waste volume based (pay as you throw)
- Economic incentives to source-separate
- Deposit-refund system for bottles and other recyclables
- Coordination with other sectors from the outset of IWMS planning

    - Energy sector
      It may also be relevant to link with energy institutions, in case incineration or biogas production is considered, especially in the case of electricity production. If energy products are produced, energy market and policy stakeholders need to be involved.
    - Agricultural sector
      It is important to link waste management with agricultural institutions. Since organic waste can be used as animal feed or transformed into fertilizers, it is important to coordinate with agricultural professionals and organizations, especially stakeholders in urban agriculture (Hofny-Collins, 2006).

      Potential sellers and users of the compost/fertilizer should be involved. That could include urban and peri-urban farmers, extension services, real-estate developers, nurseries, fertilizer wholesalers and retailers.
    - Wastewater management sector

Sewage sludge management is a major sanitation challenge in many West African cities[9], and co-treatment with sewage sludge may be beneficial technically as well as economically (Cofie et al., 2009).

In Ghana, solid waste and wastewater is managed in the same municipal department, which is an advantage if co-treatment of sewage sludge and solid waste is considered. Where solid waste and wastewater are managed by different units, coordination is needed if co-treatment is considered.

[9] The cities are largely unsewered and human excreta is managed through decentralised on-site systems. These produce faecal sludge that needs to be removed, treated and preferably recycled (Koné and Strauss, 2004).

5. GUIDE FOR IDENTIFICATION OF SUITABLE ISWMS

Guidance for identifying technological and organizational solutions adapted to the target countries regional situation, including specific examples of application:

The decision tree diagram, Figure 6-9, below has been designed to provide guidance for identifying the socio-political, technical, economical and ecological aspects that have to be evaluated in order to assess feasible options for the minimisation and handling of Municipal Wastes, Organic Wastes, Recyclable Wastes and (being a priority waste to address in most West African countries) "e-Waste".

Municipal waste

By definition Municipal wastes would include any household based waste (including the Household Hazardous Waste fraction as well as any industrial, business or informal trade waste that gets handled by a Municipality.

Organic wastes

The organic waste group by definition would include either household or business based organic waste types such as garden waste but also food waste and any other waste that could be for example either composted, worm-farmed or anaerobically digested given there is the required pre-treatment such as "chipping" or "blending" in place.

Recyclable wastes

"Recyclable Wastes" captures any waste types (either pre-consumer or post industrial) that are readily recyclable namely: paper, glass, metal and plastics.

E-wastes

Finally e-waste has been extracted being a priority waste and by definition this group contains any appliances or its components that run either on electricity or batteries. Typically outdated and broken ICT equipment and consumer electronics as well as white goods would form the bulk part of this waste stream however materials such as batteries and Compact Fluorescent lamps are also in most countries now grouped within this category.

Determine the baseline situation

The departure point for utilising this decision tree guideline towards the identification of suitable Integrated Waste Management Systems (and in order to be able to make an informed choice of subsequent mechanisms, instruments and strategies that need to be put in place) has always to be a sound evaluation of a country's, region's or municipality's baseline situation. Various key factors need to be considered in such an analysis as they provide vital clues with respect to the scope and possible success rate for an ISWM project given such external circumstances.

Standard baseline situation elements informing any decision making towards the development of a suitable IWMS are

- Demographics including the socio-economic profile of the target area
- Waste characterisation: with regard to both the amount and the types of waste generated within the target area
- Biophysical environment: the symbiosis between the physical environment and the biological life forms within the environment of the target area
- Institutional capacity: within all the government spheres concerned as well as being available through the public and private sector with regards to both human resources and skills levels
- Technical options: what is readily in place and works well or is likely to work well as an appropriate solution in the context of the other baseline elements

- Organisational structure: existing governmental reporting and HR structures as well as structures within the public and private sector that could be used for developing aspects of an IWMS
- Financial aspects: cash flow direction and budgetary cycles, existing revenue and expenditure items, general economic climate
- Legislative framework: waste laws, policies or guidelines readily in place (such as a municipal by-law on waste) and the degree of actual enforcement linked closely to available skills, human resource capacity and existing financial means.

As discussed above, each defined waste type/stream under discussion for an IWMS has to be holistically evaluated from a socio-political, technical, economic/financial and environmental /ecological point of view:

Socio-political considerations

Socio-political aspects look at elements that capture legal considerations. If a country, region or municipality decides to embrace waste minimisation as its core purpose in a future IWMS there needs to be first an official legal mandate in place to do so which can provide a clear framework of the future roles and responsibilities of each key stakeholder (e.g. households, the informal sector, private sector, NGOs, municipalities and other governmental bodies) concerned.

Existing and future enforcement capacity needs also to be established to assess the ideal mix and type of "push and pull" legal instruments applied. It makes no sense to develop legislation that is heavily built on fines or imprisonment of transgressors (e.g. for dumping or littering individuals) if the necessary control and enforcement forces are not in place. African countries are notoriously challenged when it comes to enforcement execution due to lack of skills, and human/financial resources hence positively oriented financial legal instruments that offer incentives e.g. tax breaks to industries if waste is visibly minimised (e.g. by applying Cleaner Production principles) are likely to be much more successful.

Next to the necessary law enforcement enough capacity needs also to be available for the continuous monitoring and evaluating of any strategic goals (such as waste reduction targets) and related action programmes set out as part of an IWMS. The truth applies for waste too that "you cannot manage it properly when it is not measured and monitored regularly". The development and implementation of an ISWM is not a one-time event, but has to be adapted to its regional and socio-economic conditions which are likely to change. In this case planning, monitoring and evaluating ISWM and its effects are an effective approach to develop and follow environmentally, economically and social accepted methods used in solid waste management.

Other elements that form part of the socio-political aspects which need to be considered are the provision of any suitable training, awareness and communication programmes that ultimately result in a required "behaviour change" in the targeted stakeholder group. Sadly many education attempts are futile if they do not bear fruit so it is vital that tailor-made turn-around strategies are devised for target areas that actually offer visible and therefore measurable "outcomes" (e.g. an improved litter index after education of a community has taken place).

Ongoing research and development is also important to stay abreast and informed of any latest strategic and technological trends that could be utilised as viable options for the IWMS within a target area, given its specific social, environmental and economic background.

Any potential occupational health and safety issues need to be identified and evaluated, specifically if considerations are made to build waste management strategies on large scale involvement of the informal sector or on outsourcing of certain municipal functions to the private sector by forming effective Public Private Partnerships.

Technical considerations

Any technical aspects need to capture the task at hand and prioritize interventions that yield the highest impact. Hence an IWMS needs to follow the hierarchy that gives waste avoidance and

waste minimisation at source the highest priority because "no, or less, waste generated" eases the burden of any downstream management planning and execution. Sadly historically very little attention has been given to this most important part of the waste management hierarchy and typically governments all over the world are placing their emphasis on developing and refining elaborate "end of pipe" solutions. Even "recycling projects" are end of pipe solutions because they merely mitigate the impact of an already existing waste problem and in most cases just delay the time when the material eventually becomes residual waste.

Waste Avoidance and Waste Minimisation at Source

Waste Avoidance and Waste minimisation at source is most efficiently achieved by targeting the original generator who is typically the producer of goods that become waste later. Less waste generated translates directly into fewer new resources extracted and utilised.

The Extended Producer Responsibility principle is a successful tool in some European countries and also is a core principle the South African National Waste Management Strategy. In the Netherlands, for example, costs for recycling, treatment and disposal are included in the price of a product or the producer has to take back the (used) item. The producer's responsibility has to be applied internationally and therefore countries with a lack of compliance with waste legislation would benefit from this rule: the waste and subsequent financing of its management stays the ultimate responsibility of the producer and is not simply passed on the end-consumer and/or the municipality concerned. There is therefore a powerful natural incentive to apply environmentally intelligent product design leading to goods that are less toxic, less material intensive, more easily repaired or recycled and more long-lasting.

On the other side of the coin of inefficient and wasteful production lies overconsumption. Therefore much education is required to explain to the "consumer" the pivotal role he/she plays in exercising choice when disposable, convenience products are offered that become waste almost immediately.

Segregation

Any waste that cannot be prevented or minimised from the outset should be easy to segregate in order to maximise the recovery potential of both the recyclables such a glass, metals and plastics and the organic fraction in a manner that avoids cross contamination. If a household separates dry and wet waste at source subsequent recovery rates for recyclables in a Materials Recovery Facility are typically as high as 80-90%. On the other hand, if the waste stream is unsorted, the co-mingled waste yields very little recovery potential further downstream (estimated about 5%) due to contamination issues.

Storage

In several European countries waste bins, provided by the state, are adapted to the (usually mechanised) waste collection truck. Households often have several waste bins for different waste types, such as residual waste, organic waste, paper, plastics and metal. This often depends on the region and varies according to the specific context.

In the West African target countries, however, it would be too elaborate and impractical to have several waste bins for every household. A much more basic, yet effective, "twin bin system" that keeps the recyclables separate from the contaminating "wet waste" fraction, such as is being successfully adopted by many South African municipalities, would be more appropriate. Due to low socio-economic status and bad infrastructure of many African households, individual waste bins for different materials are likely to be suitable only for institutions, industrial estates and small companies which can provide such waste types in larger amounts. For householders, waste bins can be provided at collection or drop-off points to which the waste and special waste can be brought. The collection points should be within walking distance from the households, otherwise littering and open burning may occur.

Simple waste storage solutions such as bags or sacks have to be considered as the main storage method, to be picked up easily by the waste collectors using non-motorized or motorized vehicles.

Collection & transport

In all European countries the collection of waste is carried out by motorized vehicles either door to door or via collection points. This can be applied in the target countries to some extent only, since vehicles may not be able to travel along rough roads or very narrow roads, negotiate bad weather conditions or traffic jams during the day. Secondly, the amount of waste generated is smaller than in Europe and requires smaller vehicles. Thirdly, in the less affluent socio-economic situation in the target countries and where costs for fuel are greater than labour costs, it is more beneficial to use non-motorized vehicles to collect waste from door to door and transport it to a bulk collection point which can be easily reached by a bigger waste truck to take it further to a treatment and recycling facility. This would not only create more jobs and avoid high transport costs, but also reduce air pollution from vehicle emissions.

Collection schedules have to be more frequent in target countries for organic and residual waste because the warm temperatures and excess liquid during the rainy season accelerate the waste degradation processes and therefore also the odours, leachate generation and the potential to attract flies, mosquitoes and vermin.

Recovery for reuse and recycling

One of the successful methods in European countries has been the deposit refund for glass and plastics. In the target countries this is partly practised for glass bottles. As a rule of thumb, any "waste materials" with value (either intrinsic or artificially created e.g. in the form of a levy) will, in a free yet poverty challenged economy, be "automatically" collected by private entrepreneurs and members of the informal sector.

Waste bins provided e.g. by the state or a recycling company, can also be an option. However, to encourage bringing wastes to a drop-off point for collecting receptacles, incentives must be created. In this case collection spots may pay cash to residents bringing in recyclables.

Waste2Art and Waste2Product-oriented livelihood projects offer both recycling of material to a small extent and the creation of employment. Here paper, plastics and metals can be used to make bags, bracelets, earrings and other small items which yield a much higher added value than if the waste material were sold to a conventional large scale recycler.

Household hazardous waste types including e-waste

For certain kinds of special or hazardous wastes, special containers at convenient drop off points can be provided. Hazardous waste should not be disposed of together with the other general waste and people should be able to bring it to the collection point for free. In several European countries special bins or special collection days are observed.

Treatment

Organic waste

Composting at household level or collection of the organic waste fraction is widespread in some European countries. Organic waste is transported to large scale composting plants. In the target countries some organic waste will be utilized as food for animal husbandry, while backyard composting would provide several benefits. Organic waste could also be collected at a community level or through be processed at decentralized small composting enterprises which can sell the compost to farmers and gardeners. Obligatory for composting is the segregation of organic wastes so that they are free of other residual wastes. These wastes are then shredded and placed in windrows for composting, using labour intensive processes rather than heavy machines.

Residual Waste

Residual waste coming from both industrial/business/trade as well as from household sources can be mechanically sorted to further separate out recyclables and treated to reduce its volume.

Hazardous Wastes

There may be particular requirements for the disposal of hazardous waste components (e.g. heavy metal contaminated industrial waste sludge) and waste types such as health care risk waste that might need elaborate pre-treatment, or alternative treatment such as incineration or encapsulation prior to landfill

Final disposal

The most appropriate final disposal option for the West African target countries is landfilling, which has to comply with many requirements for the design, operation and maintenance of such sites. These requirements include technical specifications for plant and equipment, operational requirements for the development of the site, environmental controls to contain emissions of landfill gas, leachate (e.g. via landfill cell liners) and minimise other nuisances, environmental monitoring and auditing and health and safety management for worker safety.

Economic and financial considerations

Economic and financial aspects that need to be addressed as part of an IWMS include the establishment of rates and taxes that cover the expenses for the tasks ahead. The City of Cape Town's recent evaluation on Alternative Service Delivery systems went to great length to cost various municipal waste minimisation intervention options (as part of a Full Cost Accounting analysis based on the ring-fencing of the individual line budgets for collection, cleansing and disposal to establish true costs) and sadly in the African context "landfilling" is likely to remain from a purely economic perspective the cheapest option. Any add-on services linked to waste beneficiation programmes such as increased recycling and composting are coming at an additional price tag and budgets have been recently adjusted accordingly that will see an increase of 38.5% in municipal rates to finance the City of Cape Town's new mandate of truly minimising waste going to landfill.

Clearly the original generators of the waste problems – the industrial producer needs also to be taxed to absorb such costs or, alternatively, incentives have to be devised to encourage waste prevention at source. Municipal operations need to be financed sufficiently in the allocated municipal budget so "cost recovery mechanisms and services" need to be identified accordingly.

One powerful avenue is the prospect of carbon trading in the form of the Clean Development Mechanism projects where capital investments are covered by third parties (typically highly industrialised countries with a huge carbon footprint) who can aid other countries to minimise their own.

Extracting renewable energy from waste (e.g. through bio digestion and subsequent utilisation or conversion of methane gas into electricity) is also an increasingly interesting field of application to investigate for African countries in the face of a mounting global energy crises.

Finally avenues for donor funding need to be fully explored- there is much support and financial partnership potential if countries do some homework on options available. An IWMS needs to be at all times economically viable while continuously exploring social benefits such as public/private sector employment opportunities from waste. To ensure sustainable markets that offer materials of high quality of high demand it is important that any future IWMS is geared towards the development of a resilient national and, even more so, local recycling economy.

Ecological considerations

Finally the ecological aspects need to be identified. The reality of waste management in Africa and most countries in the world shows that this is often the most neglected area and often ignored or overlooked as part of a comprehensive and thorough analysis that should underpin any IWMS.

Environmental Impact Assessments are a crucial tool to investigate the possible impacts of waste management practices with regard to possible pollution of the surroundings in the air, water and soil of a target area next to posing a direct threat to human health and safety. They form the basic foundation that permits a new infrastructural development (such as a landfill site) or a specific waste management activity and when in place it is vital to provide for an ongoing monitoring and auditing schedule as part of the overall environmental management plan. The socio-economic aspects that would also form part of an impact assessment have been dealt with above.

Integration of the selected SWM systems

If all of the above factors are taken into account in the choice of suitable technologies and supporting institutional arrangements, it should lead to the development of an Integrated Solid Waste Management Plan, which can be sustainably implemented for the particular context under consideration within the target countries. Such a plan would also, therefore, include a review process which allows for the monitoring of the implementation of the plan, review and revision for continuous improvement.

Whatever elements and strategies are chosen to form part of IWMS deemed suitable for a country (with its unique mix of specific challenges and opportunities) the principle of "good governance" needs to guide the decision makers when discussing possible methods and techniques to be used in solid waste management. The principle of "good governance" is important in order to succeed and to provide not only a well established SWM but also ensure its compliance and enforcement.

Fig. 5: Guide for identification of suitable Integrated Solid Waste Management Systems

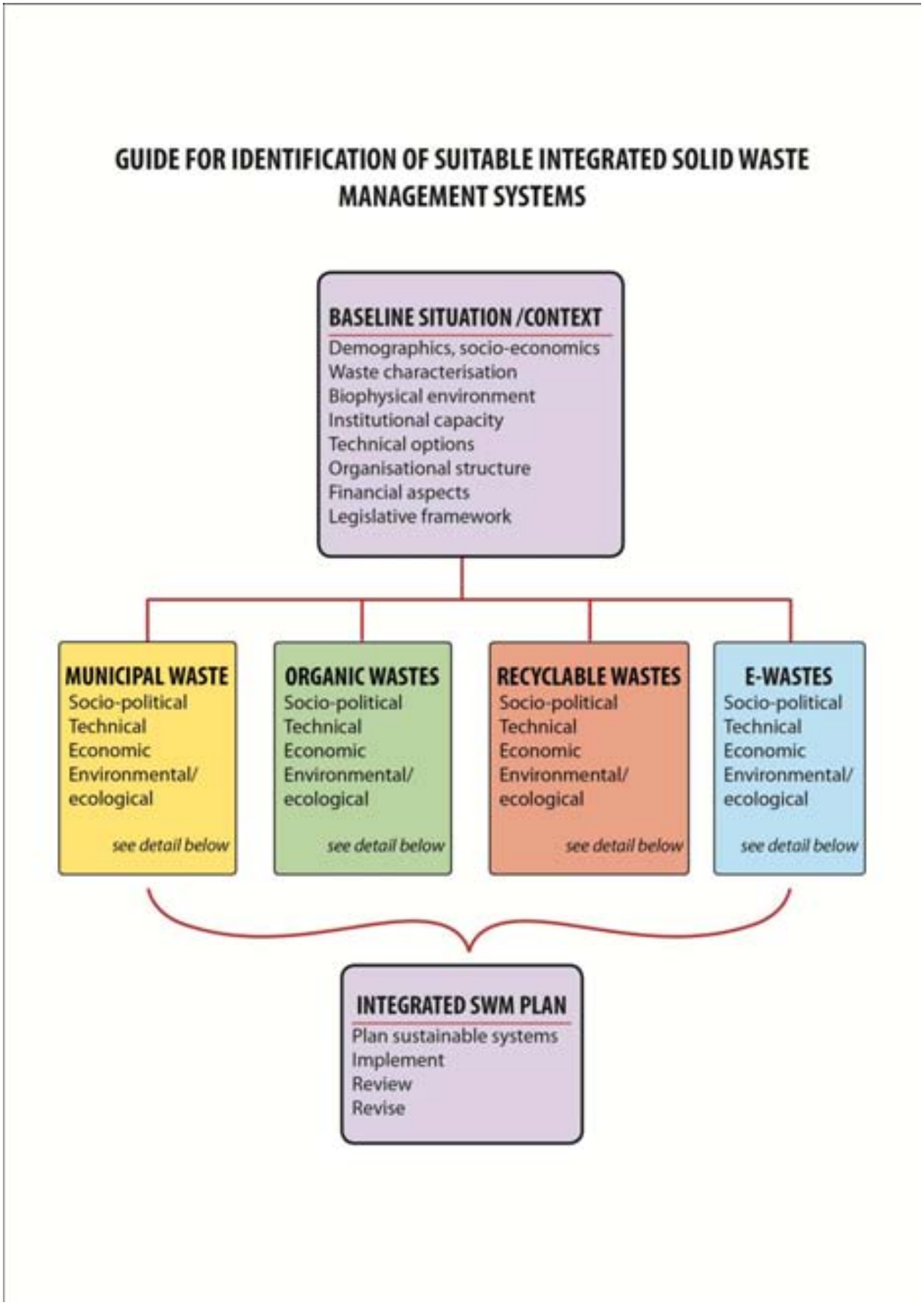


Fig. 6. Guide for Municipal Solid Waste Management Systems

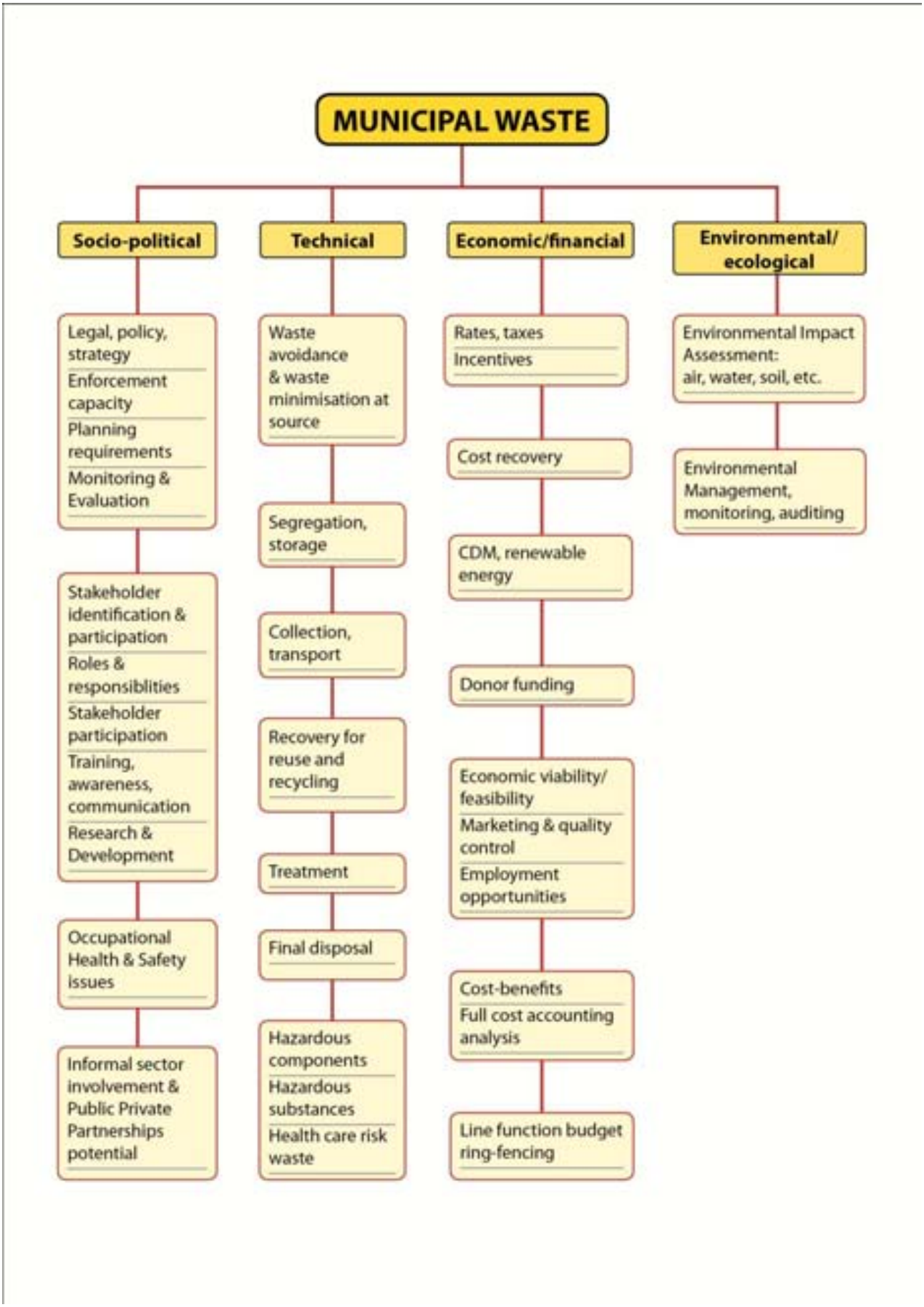


Fig. 7: Guide for Organic Waste Management Systems

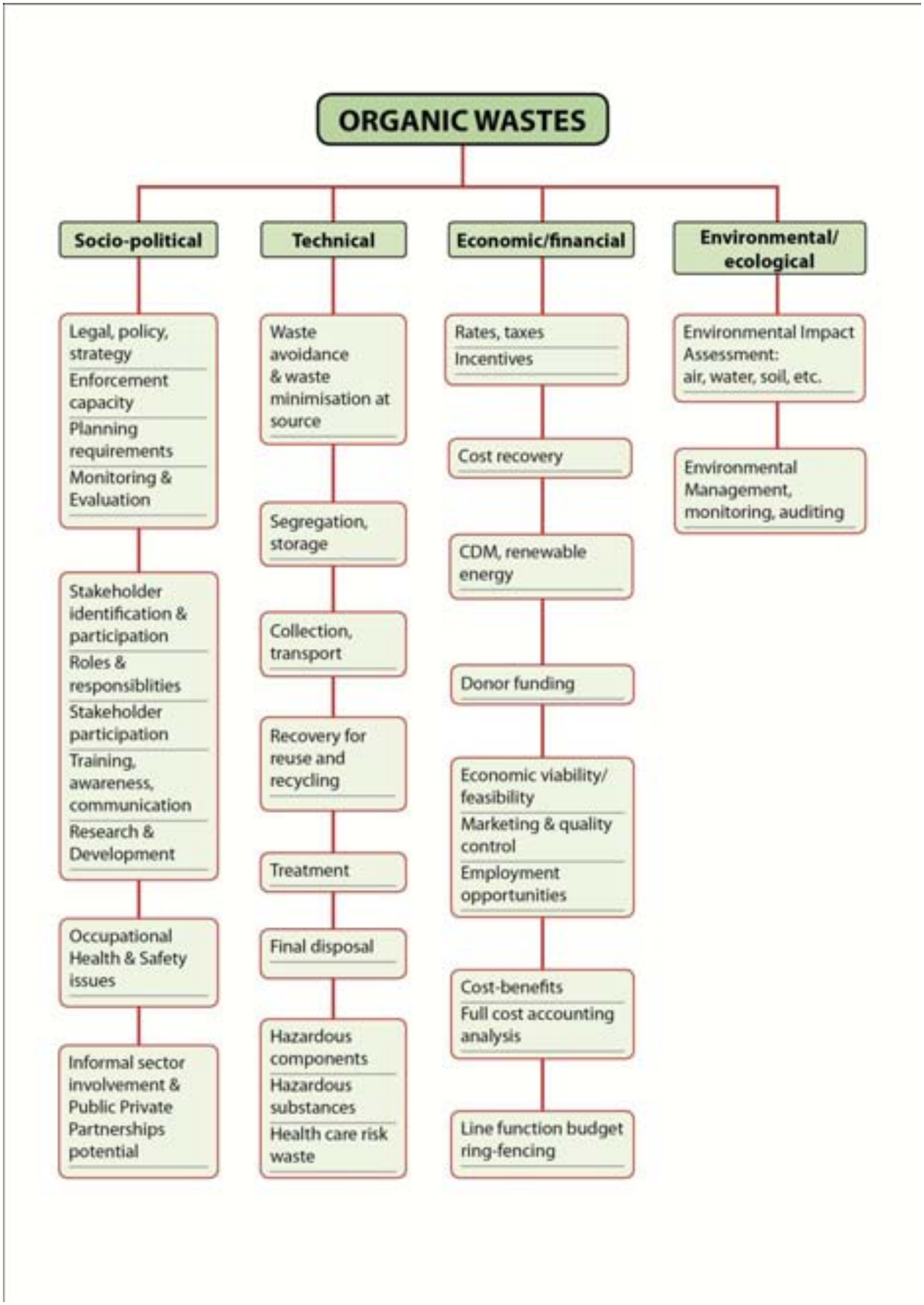


Fig. 8: Guide for Recycable Waste Management Systems

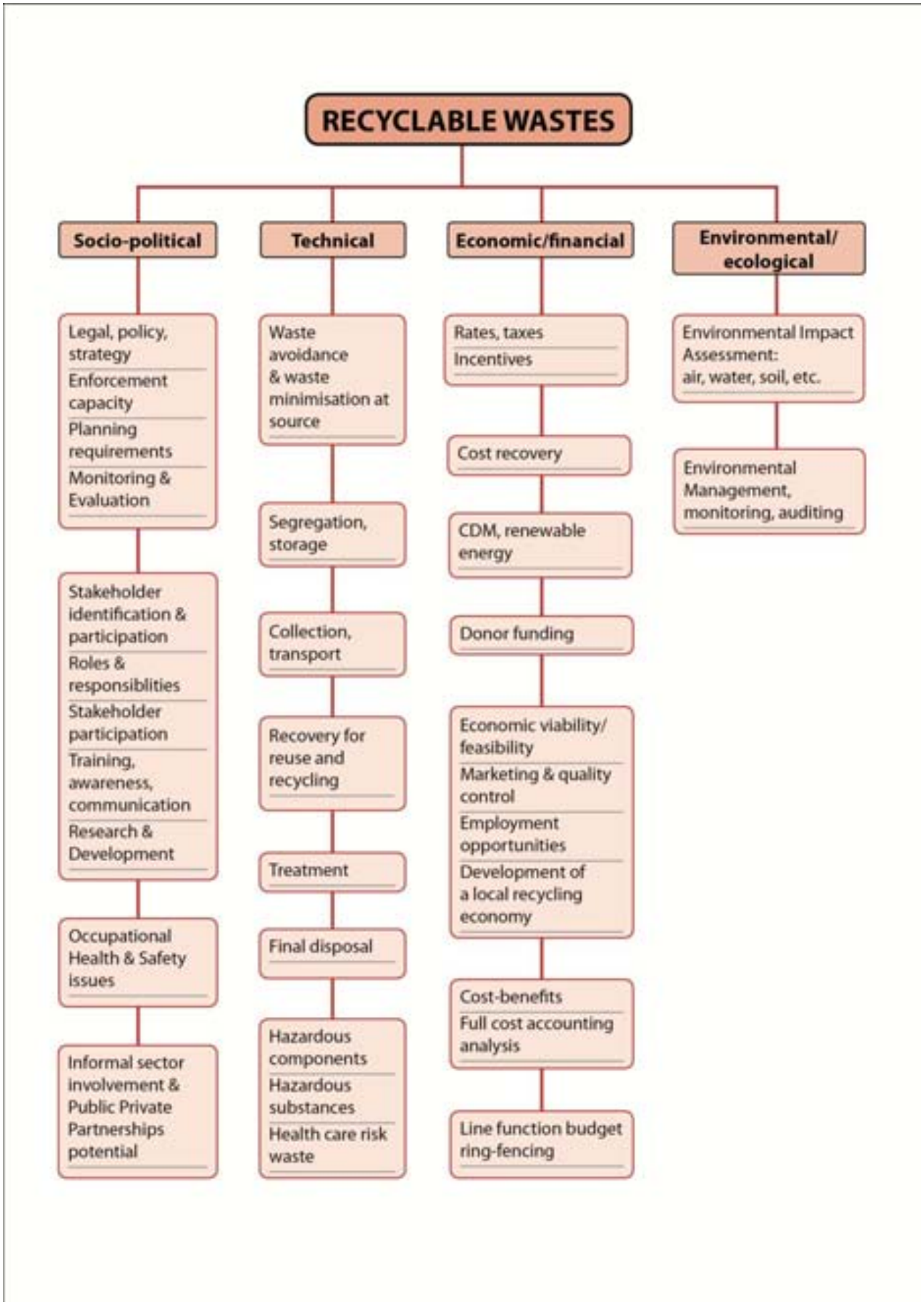
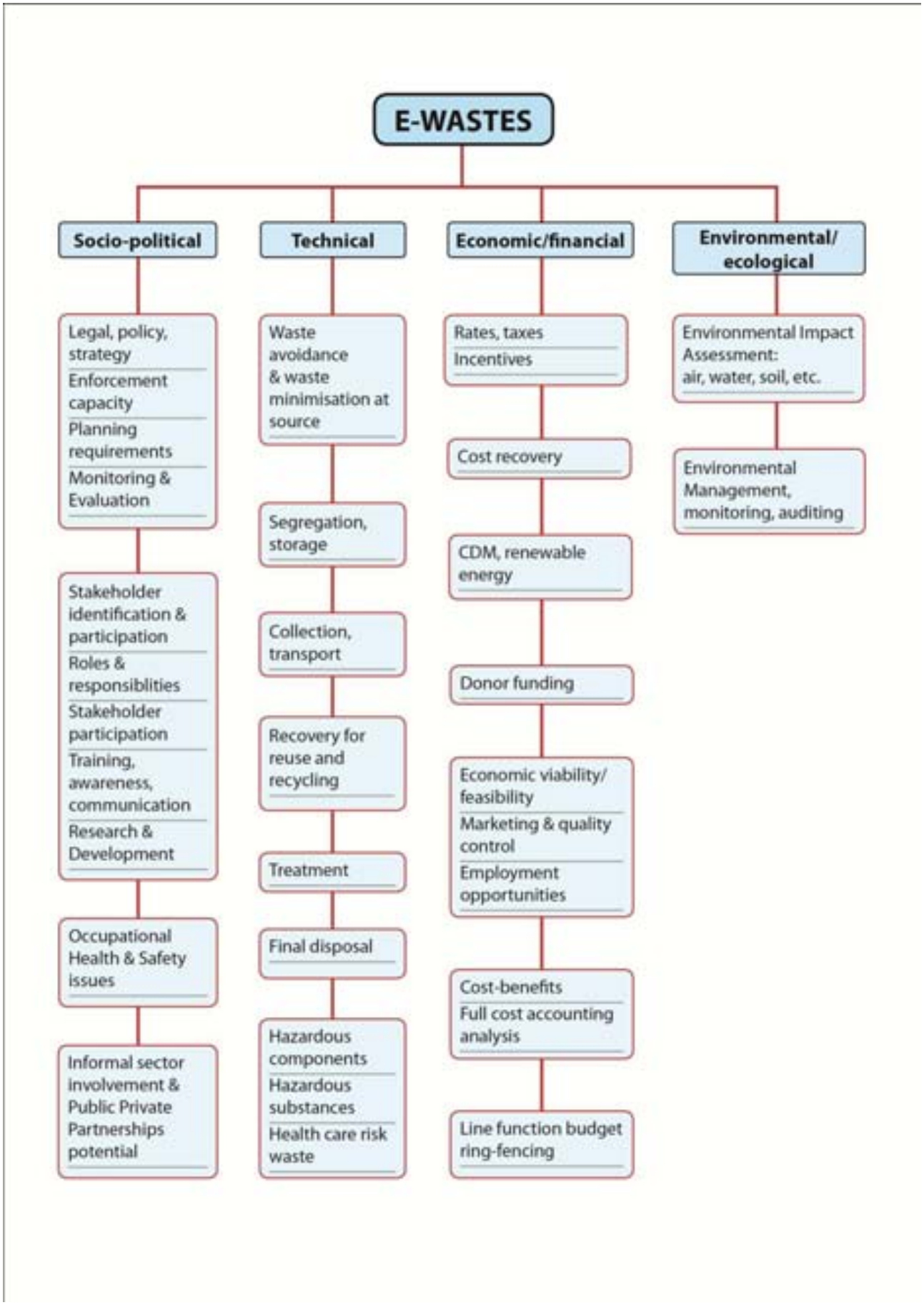


Fig. 9: Guide for E-waste Management Systems



6. REFERENCES

Akhile Consortium; 2010, Draft Status Quo Report: MSA Section 78 (3) to Assess Alternative Service Delivery Options; RFP NO: 554C/2008/09; Internal Document City of Cape Town

Appiah Boamah, L. (2011), Environmental Sanitation Policy of Ghana (2010) and Stakeholder Capacity: a case study of solid waste management. MSc Thesis Sustainable Development Programme, Uppsala University, Uppsala, Sweden.

Boström, A. (2010). Decentralized composting instead of landfilling of organic waste - greenhouse gas reduction from a potential CDM project in Kumasi, Ghana. MSc thesis, Department of Energy and Technology. Uppsala, Swedish University of Agricultural Sciences. http://www.w-program.nu/filer/exjobb/Andreas_Boström.pdf

Cavana, R.Y. and Maani, K.E. 2000. A methodological framework for Systems Thinking and Modelling (ST&M) Interventions. 1st International Conference on Systems Thinking in Management (ICSTM)- Geelong, Australia 2000. [Online]. Available: http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-72/019%20Cavana%20Methodological.pdf

CCN & UNEP, 2010. Integrated Solid Waste Management Plan for the City of Nairobi, Kenya: Situation Analysis & Detailed Action Plan. City Council of Nairobi & UNEP - Nairobi Office, Kenya.

Coetzee. B (City of Cape Town Manager: Technical Strategic Support (Utility Services).2011. Integrated Waste Management Beyond Legislation Towards Implementation

Cofie, O. O., P. Drechsel, et al. (2009): "Resource recovery from urban waste: Options and challenges for community-based composting in sub-Saharan Africa" Desalination 248(1-3): 256-261.

Friedrich, E. and C. Trois (2011): Greenhouse gases accounting and reporting for waste management - A South African perspective. Waste Management, In Press.

GTZ (2005): Private Sector Involvement in Solid Waste Management: Avoiding Problems and Building on Successes, Division 44 Environment and Infrastructure, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, 2005, 261 pages.

Hofny-Collins (2006): The Potential for Using Composted Municipal Waste in Agriculture: The case of Accra, Ghana. Department of Urban and Rural Development. Uppsala, Sweden, Swedish University of Agricultural Sciences. Doctoral Thesis: 349 http://epsilon.slu.se

Jackson, M.C. 2008. Systems Thinking: Creative Holism for Managers, John Wiley & Sons Ltd, USA.

Kasozi, A.; and von Blottnitz, H. (2011): Applying systems thinking in the development of an ISWM Plan harnessing semi-formal systems in Nairobi: Lessons for expanding waste management services in Africa

Mebratu, D. 1998. Sustainability and sustainable development: Historical and conceptual review. Environmental Impact Assessment Review. 18(6):493-520.

Nzeadibe, T. and C. Ajaero (2011). Development impact of advocacy initiatives in solid waste management in Nigeria." Environment, Development and Sustainability 13: 163-177.

Rothenberger, Zurbrugg et al., (2006). Decentralized composting for low- and middle-income countries - A user's manual. Waste Concern, Dhaka, Bangladesh, and EAWAG, Duebendorf, Switzerland. In http://www.eawag.ch/forschung/sandec/publikationen/swm/dl/decomp_Handbook_loRes.pdf

UN HABITAT (2010).Solid Waste Management in the World's Cities, Water and Sanitation in the World's Cities, United Nations Human Settlements Programme, Earthscan, London and Washington, D.C