State of Waste Management in Cities – Phase 2

Modelling the effects of landfilling as a disposal method

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Executive Summary

Urbanisation and population growth has resulted in increased generation of solid waste, which places increasing pressure on waste management within cities. As this trend continues, the drive to seek less impacting methods associated with disposal and increased focus on recycling, separation and re-use of waste is to be further explored and implemented. The shift on reducing waste to landfill is forcing cities to look at suitable alternatives and reconfigure their planning for the future.

This report demonstrates the impact of relying on landfilling as the main disposal method for solid waste. The main output is a model that can be used to further underscore the negative impacts of waste non-recovery within the following cities:

- City of Cape Town Metropolitan Municipality (CoCT)
- City of Johannesburg Metropolitan Municipality (CoJ)
- City of Tshwane Metropolitan Municipality (CoT)
- eThekwini Metropolitan Municipality
- Ekurhuleni Metropolitan Municipality (EMM)
- Mangaung Metropolitan Municipality
- Nelson Mandela Bay Municipality (NMBM)
- Msunduzi Municipality
- Buffalo City Metropolitan Municipality (BCMM)

As an attempt towards finding solutions, the report also provides recommendations on strategic interventions required to curb the impacts which includes; institutional arrangements, policies and procurement processes. Waste indicators were developed in 2013 during the write-up of the State of Waste Management in Cities Report. These have further been refined and incorporated into a model for use by each city and projected against a 2030 timeline.

Integrated Waste Management Plans

There is inconsistent development of Integrated Waste Management Plans (IWMP) across the participating cities. At the time of writing the report only two cities complied with the development of the IWMP i.e. existence of an IWMP that gets reviewed regularly, these cities were CoCT and CoJ. Other cities either had an outdated IWMP or not even in the process of developing such a plan. This has a direct impact on the ability to deliver waste management services as such cities do not have a guideline to follow in the form of an approved IWMP.

To ensure that IWMPs are prioritized within municipalities it is necessary that these plans form part of the Integrated Development Plans. The IWMPs must be outcome focused, with priorities, objectives, targets, implementation and financing arrangements and must be realistic to the specific circumstances in each area.

Airspace

Landfills in most South African cities have limited airspace and with continued disposal to landfill, their airspace availability is becoming a concern. Compliance to legislation and implementation thereof is equally important to ensure sustainable solutions and practices are put into place and adhered to. Projections from the model clearly depict the state of waste management along these attributes in the following responding cities.

CoJ

The waste tonnages extrapolated from the model are in direct relation to population trends within CoJ based on projected generation rates. The graph indicates that airspace within CoJ will diminish within the modelled time period by the year 2025. This result is consistent with the recorded population growth for the city as well as anticipated future growth due to urbanization.

The rate at which the airspace diminishes can be reduced in the city if greater efforts are made to divert waste from landfill to other uses (reducing, reusing, recycling etc.).

Population is growing steadily and this can be attributed to factors e.g. urbanisation, influx from people from surrounding provinces. CoJ is the economic hub of South Africa and there are profile changes in the socio economic levels. Most of the waste facilities are located in the southern regions and this creates challenges for the treatment and disposal of waste in the northern regions of CoJ. As a result large amounts of waste are being transported across the city. The Northern part of CoJ is highly economically active producing various waste streams due to development. With the absence of waste facilities in the Northern region waste is being diverted to private waste facilities. Adequate planning and the timing of developing new waste infrastructure and alternative waste treatment facilities have not been forthcoming. This has resulted in the current limited landfill airspace availability.

CoCT

The CoCT is the only city that faces depletion of its airspace halfway through 2030. Based on generation rates and current waste tonnages, the graph indicates that airspace within CoCT will deplete by 2023.

There are currently active programs for waste separation and recycling in the metro and this is contributing towards the savings in airspace to some degree. There are strategic plans in place to manage the landfill infrastructure requirements for the future and efforts towards private partners involved as well. The development of further MRFs and alternative waste technologies will need to be broadly assessed to provide an adequate solution. The waste generation volumes are relative however the timelines for new facilities need to be addressed sooner.

eThekwini

Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within eThekwini. The model and adjacent graph indicates that airspace within eThekwini will be 3.7 million m3 as of the year 2030. Due to an increase in waste generation from 2021, the model also indicates that waste will be produced above airspace available.

There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. The metro has effective waste collection systems and does take steps to educate communities on recycling and engages with the greater public on recycling and reduction programs. With the continued growth in the city, the metro is continuously planning for landfill airspace and is also planning for a new mega landfill to the west of the city. The pro-active steps must continue to evolve and the process towards reducing waste to landfill should be a priority on the planning schedule.

CoT

Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within CoT. The model and adjacent graph indicates that airspace within City of Tshwane will be 36 million m^3 as of the year 2030. Due to an increase in waste generation from 2029, the model also indicates that waste will be produced above airspace available.

There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. The graph depicts a situation of immediate intervention to call upon expertise to render technical support and the development of a waste reduction strategy to landfill which will outline immediate and long term planning. As a key metro and with continued growth, the existing landfills and the infrastructure are going to come under extreme pressure. The lack of appropriate skills and introducing suitable disposal methods are negatively impacting on the available airspace. Planning for new integrated waste facilities need to be initiated now to manage the situation.

EMM

Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within Ekurhuleni. The model and adjacent graph indicates that airspace within Ekurhuleni will be 25 million m3 as of the year 2030.

There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. One of the key challenges in the metro is that all of the existing landfills are on the outskirts of the metro and none in the high density or high income areas. The challenge is the logistics and distances to travel which creates its own impacts. The growth of the informal areas and natural progression of these communities into different economic classes will progressively develop different waste streams resulting in large waste volumes leading to the metro being forced to consider alternatives. Reclaimers do exist on some of the landfills and with their involvement on the landfill it can be seen some of the waste streams are being recovered for recycling. Key going forward is for an implementation plan for waste minimization and a phased plan for reduced waste to landfill in conjunction with considering other technologies.

Mangaung

Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within Mangaung. The model and adjacent graph indicates that airspace within Mangaung will be 25 million m3 as of the year 2030.

There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. The city has 3 large landfills however the current deposition methods and operational standards are not sustainable for long term landfill availability. The lack of sufficient resources and support in the waste department contributes to the existing problem. Further to this, the presence of reclaimers on the landfills poses a challenge in terms of risk and health issues. With the reclaimers on the landfills, they are undertaking their own scavenging of materials and creating a bigger challenge for the metro in managing the disposal process. There is no recycling happening in the formal sense and as a result the airspace is being rapidly being utilized. Waste streams such as builders rubble is mixed in large quantities with municipal waste. There is a real opportunity to introduce separation, recycling and composting at household and landfill levels.

Recycling

It can be noted from the model, CoCT recycles on average 1.21%, eThekwini 1.99% and Ekurhuleni 0.26 % of the total tonnages of waste generated. CoCT has a different profile of recycling in comparison to the other cities; this may be due to the following factors that are implemented by CoCT:

- The City has a defined waste minimisation strategy.
- Recycling initiatives are outsourced to contractors.
- City has an established MRF (Kraaifontein).
- By-laws and policies are clear on recycling.

Although this amount of recycling seems low it is not considered a true reflection of the efforts of these cities as there are still gaps in the data management. It should be noted that this figure excludes private recycling initiatives. Metropolitan municipalities globally are more successful in achieving higher recycling volumes as they have access to adequate funding and resources. They are in a position to allocate funds to education and awareness campaigns.

Waste to Energy

Conversion of waste to energy falls low in the hierarchy of waste management. It is less preferred in comparison to “reduce, reuse and recycle” because it does not impact on the volume of waste generated or reduce the pressure on the landfill. Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel. Using energy recovery to convert non-recyclable waste materials into electricity and heat, generates a renewable energy source and can reduce carbon emissions by offsetting the need for energy from fossil sources as well as reduce methane generation from landfills.

A number of waste to energy (WtE) projects have been initiated in the cities where eThekwini is the front runner generating 1.1MW and 6.5MW electricity harnessing the power from Landfill gas (LFG) at Marianhill and Bissasar Road landfill sites respectively.

Critical success factors

CoJ

Regardless of waste diversion and waste minimisation efforts, establishment of a new landfill site will be required. The scale (size/ capacity) of the new site should be informed by the rollout of waste minimisation actions.

It is recommended that strategies to minimize waste to landfill should be increased. Although CoJ currently has successful small-scale waste to energy projects as well as separation at source, implementation of waste treatment alternatives should be further investigated and adopted if proven feasible.

It is also suggested that the following be implemented:

- Explore alternative waste treatment technologies
- Introduce MRF's in various regions
- Increased community collection
- Operational improvements
- Implementation of the Waste Minimisation Strategy

CoCT

CoCT is considering PPP models to manage waste more effectively by creating synergies with Waste Water Treatment Plant (WWTP) for energy recovery, composting and MRF's leading to energy recovery which will in turn save landfill airspace. It is recommended that strategies on a minimisation drive should be increased as well as implementation of waste treatment alternatives.

Establishment of a new landfill site is critical and urgent, as this will be required regardless of waste diversion and waste minimisation efforts (see Figure 2). The scale (size/ capacity) of the new site should be informed by waste minimisation actions. It is also suggested that the following be implemented:

- Roll out of the Waste Minimisation Plan
- Involvement between technical advisory and government to build on a PPP model for inclusiveness and success
- Consider synergies with Waste Water Treatment Works and Landfills for co-generation of gas (Waste to energy)
- Development of more MRF's

Mangaung

Strategies toward waste minimisation drives should be effectively assessed to encourage reduced waste to landfill and direct community behavioral patterns towards waste disposal. The availability of the current footprints of the three landfill sites presents an ideal opportunity to develop an integrated waste management facility, i.e. WtE facility, MRF, Composting plant and a crushing and screening plant. This should be investigated and implemented if feasible.

It is also suggested that the following being implemented:

- Consider operational intervention, i.e. “Back to basics” on landfills
- More planning directives for It is recommended waste collection and separation
- Weak resources and skills at municipal level to carry out or support policies
- Develop a socio-model to engage the reclaimers to be “on-boarded” in the recycling programme at the landfill sites
- Greater education and awareness initiatives at community level in order too
- Excessive number of reclaimers, safety is a key concern
- Mixing of different waste streams e.g. builders rubble mixed with organics.
- Initiative to establish cooperatives for reclaimers.

eThekwini

eThekwini has successful programmes with regards to waste minimisation and it is advised that strategies are phased in the approach towards waste minimisation planning. Although this city currently has successful waste to energy projects, implementation of waste treatment alternatives should be further investigated and adopted if proven feasible.

As Bisasar Road Landfill is due for closure, eThekwini is considering a regional (mega) landfill site to manage waste from the whole of municipal area. The municipality is investigating developing localized landfills, with MRFs, such as Buffelsdraai landfill site to the North of the municipality.

Buffalo City

BCMM is faced with the challenge of adequately planning for short, medium and long term which has resulted in the current situation of minimal airspace, no new cell development, poor operational standards and lack of resources.

It is suggested that the following being implemented:

- Strategic planning intervention: Assess full waste generation to disposal cycle
- Waste Minimisation plan- engagements with stakeholders for buy in.
- Engagement with reclaimers to be inclusive in the separation and recovery initiatives on the landfill
- Explore waste treatment alternatives to be considered at the landfill as part of the integrated model.

Msunduzi

The New England Road landfill site is challenged with numerous reclaimers on the working face which poses health and safety risks. This further impact on the operations and planning processes for the officials.

It is suggested that the following being implemented:

- Look at a waste strategy inclusive of all the towns to implement a wider waste management solution.
- Develop a formal system for the number of reclaimers to deal with waste recycling and recovery
- Include greater planning around logistics, and allow for waste services for informal areas.

CoT

Regardless of waste diversion and waste minimisation efforts, establishment of new cells on the existing landfill sites to bring about capacity for residual waste. The aged infrastructure creates challenges in terms of securing and operating the landfill sites in a compliant manner. The implementation of waste treatment alternatives is currently being investigated by CoT and should be implemented if proven feasible.

It is also suggested that the following being implemented:

- Establishment of a regional landfill site should be investigated and considered.
- Develop a comprehensive waste management strategy

- Technical support to direct the current landfilling operations and identify gaps that could be used in the assessment of alternative waste treatment Look at phased planning approach.

EMM

The current challenge in EMM is the lack of waste minimization approaches and the development of integrated waste management facility.

It is recommended that strategies toward a phased approach of waste minimisation planning should be increased. EMM currently has landfill gas projects at some of their landfill sites. Implementation of waste treatment alternatives should be further investigated and implemented if feasible.

It is also suggested that the following being implemented:

- Investigation of alternative waste disposal facilities to deal with rural waste
- Explore alternative waste treatment technologies
- Consider central area for disposal as landfill sites are not in close proximity to generation points
- Provision of adequate resources i.e. fleet Consider community based waste collection, i.e. job creation.

Identified gaps	**Proposed actions**
Development of best practice in waste prevention policy and programmes	Develop integrated resource policies, spanning the life-cycle of resources used in various goods and products.
Clean development mechanisms (CDM) and Joint implementation(JI) methodologies for waste prevention practices, and to account for GHG savings gained through resource recovery (i.e. recycling).	Support research into viable methodologies for waste minimisation projects (i.e. validating GHG savings from materials recovered for recycling). Identify projects eligible for CDM and JI
Promotion of best-practice resource recovery systems and processing.	Investigate climate impacts of recycling processes and resource recovery
Support for informal recycling sector.	Promote legalisation of the informal waste sector Provide reclaimers with resources to form cooperatives, access funds for improved equipment, and agree on contracts for access to waste sources. Prepare strategies to ensure protection of livelihood and improvement of quality of life of the informal recycling sector.
Develop strategies for financing of waste management activities	Develop strategies for the initiation and continuation of financing for waste management. Priority should be given to development of local, sustainable funding mechanisms (i.e. waste disposal fees, public-private partnerships, out-sourcing to private sector). Ensure that funding emphasis is equally placed on waste collection systems and logistics, not only capital and infrastructure.

Acronyms

BCMM	Buffalo City Metropolitan Municipality
CDM	Clean development mechanism
CO_2	Carbon dioxide
CH_4	Methane
CoCT	City of Cape Town Metropolitan Municipality
CoJ	City of Johannesburg Metropolitan Municipality
CoT	City of Tshwane Metropolitan Municipality
DoE	Department of Energy
EMM	Ekurhuleni Metropolitan Municipality
GDP	Gross domestic product
GHG	Greenhouse gas
IPP	Independent Power Producer
IWMS	Integrated Waste Management System
IWMP	Integrated Waste Management Plan
JI	Joint implementation
LFG	Landfill Gas
LCA	Life cycle assessment'
MMM	Mangaung Metropolitan Municipality
MRF	Material Recycling Facility
NEMWA	National Environmental Management: Waste Act, 59 of 2008
NWMS	National Waste Management Strategy
NMBMM	Nelson Mandela Bay Municipality
PPP	Public Private Participation
WtE	Waste to Energy

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1. Introduction

AURECON was appointed on behalf of the client, South African Cites Network (SACN) to undertake Phase 2 of the Project: “State of Waste Management in Cities”. The specific objective of Phase 2 of the project is to provide empirical evidence for non-recovery of waste in various cities. Limited data verification is meant to play a key role in determining this evidence as this was done through phase 1. The main output of the project is a model that can be used to further underscore the negative impacts of waste non-recovery within our cities. Embedded within this objective is an investigation of into the contribution of poor waste management to exacerbating climate change impacts.

As an attempt towards finding solutions, the report provides recommendations on strategic interventions required to curb the identified negative impacts e.g. institutional arrangements, policies and procurement processes.

A more sustainable waste management system will contribute to an increased efficiency usage of natural resources, and to decrease environmental impacts. To achieve sustainability, the waste management must also be affordable and widely accepted by the public as well as by other key stakeholders i.e. Government and public. Phase 2 also identifies instruments and other strategic decisions that contribute to the development of a more sustainable waste management approach.

The following nine member cities of the SACN participated in Phase 2 of the project (See Annexure A):

- City of Cape Town Metropolitan Municipality (CoCT)
- City of Johannesburg Metropolitan Municipality (CoJ)
- City of Tshwane Metropolitan Municipality (CoT)
- eThekwini Metropolitan Municipality
- Ekurhuleni Metropolitan Municipality (EMM)
- Mangaung Metropolitan Municipality
- Nelson Mandela Bay Municipality (NMBM)
- Msunduzi Municipality
- Buffalo City Metropolitan Municipality (BCMM)

2. Background

The Phase 2 of the State of Waste Management project built on what was previously initiated by the Phase 1 of the project. Phase 1 involved the analysis of pre-collected city data on waste management, using waste management indicators developed together with the cities. This project report provides the status of waste management in cities, using the 2011/2012 financial year data as a foundational baseline that could be used to inform the 2016 State of Cities Report on waste management.

The project analyzed the common but differentiated capabilities of cities in respect of waste management services; in particular the performance of different waste management models over time and lastly, a comparative analysis amongst cities was done in terms of the indicators (Refer to Appendix B). Some progress in terms of how and where things are done in relation to waste management in cities was achieved during the Phase 1 of the project.

The following are the key challenges and findings from the Phase 1 report regarding the participating cities were noted:

2.1. Waste Management Challenges

- Institutional and governance structures for waste management services in some cities are not clearly defined.
- Lack of municipal policies and governance frameworks for waste management.
- Limited budget allocations and financial resources for waste management.
- Lack of proper supporting instruments, framework and resources from the national government on waste hierarchy, has impacted negatively on a city's ability to develop programs on waste recycling, reuse and reduce.
- At the national level, lack of supporting mechanism including resources for the rehabilitation of old landfill sites; while at the municipal level, compliance to landfill licensing conditions and requirements is still a challenge.
- The unprecedented growth of cities.
- Lack of proper city reporting, data and information on waste management services.
- Illegal dumping.
- Lack of coordination between a city and private waste service providers in relation to systems and joint reporting mechanisms.

2.2. Findings

- Waste collection in all cities is above the national average of 65%.
- Increase on waste collection since 2001 is observed, with Mangaung recording a waste collection service increase of more than 10% between 2001 and 2011.
- Three best performing cities in terms of waste management who have up-to date and functional IWMPs is as follows:
  - City of Johannesburg,
  - City of Cape Town and
  - NMBM.
- The waste industry presents opportunities for job creation, energy generation and value-add through recycling, i.e. eThekwini municipality supplies electricity to more than 5000 households as a result of waste to energy initiatives.
- Governance structure should be strengthened, while financing for waste collection is reviewed to reflect the correct cost of managing waste from cradle to grave.

3. Regulatory Framework in Waste Management

While this not a comprehensive review of all legislation, the legislation applicable to this report includes:

3.1. National Environmental Management: Waste Act, 59 of 2008

The National Environmental Management: Waste Act, 59 of 2008 (NEMWA) provides the definitions of waste as well as the listed activities that require licensing. This Act also provides specific waste management measures for remediation of contaminated land as well as for compliance and enforcement. Waste and waste management activity as amended by Act 14 of 2013[1] is defined as follow:

“**"waste**" means:

a) any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act; or
b) any other substance, material or object that is not included in Schedule 3 that may be defined as a waste by the Minister by notice in the *Gazette*,

but any waste or portion of waste, referred to in paragraphs (a) and (b), ceases to be a waste—

i. once an application for its re-use, recycling or recovery has been approved or, after such approval, once it is, or has been re-used, recycled or recovered;
ii. where approval is not required, once a waste is, or has been re-used, recycled or recovered;
iii. where the Minister has, in terms of section 74, exempted any waste or a portion of waste generated by a particular process from the definition of waste; or

where the Minister has, in the prescribed manner, excluded any waste stream or a portion of a waste stream from the definition of waste.””

“**"waste management activity**" means any activity listed in Schedule 1 or published by notice in the Gazette under section 19, and includes:

a) the importation and exportation of waste;
b) the generation of waste, including the undertaking of any activity or process that is likely to result in the generation of waste;
c) the accumulation and storage of waste;
d) the collection and handling of waste;
e) the reduction, re-use, recycling and recovery of waste;
f) the trading in waste;
g) the transportation of waste;
h) the transfer of waste;
i) the treatment of waste; and
j) the disposal of waste.””

3.2. The National Waste Management Strategy

The National Waste Management Strategy (NWMS) is a legislative requirement of NEMWA. The purpose of the NWMS is to achieve the objects of the Waste Act. Organs of state and affected persons are obliged to give effect to the NWMS.

Municipalities should move away from traditional “end of pipe” solutions that focus on waste after it has been generated i.e., collection, transport, processing, recycling or disposal of waste material to a service which focuses on the prevention of waste as well as the minimisation of waste as a by-product of production. This approach is recognition of the widely adopted waste hierarchy (see Figure 1) which includes the 3Rs of waste management i.e., reduce, reuse, and recycle as well as energy recovery. Only after these efforts, should the residual waste be disposed of at landfill. The delivered service must maximise efficiency and minimise environmental impacts and financial costs with the ultimate aim of improving quality of life.

The waste management hierarchy can be viewed as a simple set of management plans for waste. The hierarchy sets forth several waste management strategies or options according to importance and preference in a descending order. The aim is to extract the maximum practical benefits from the products and manage waste in the best possible manner, so that the minimum amount of waste is generated.

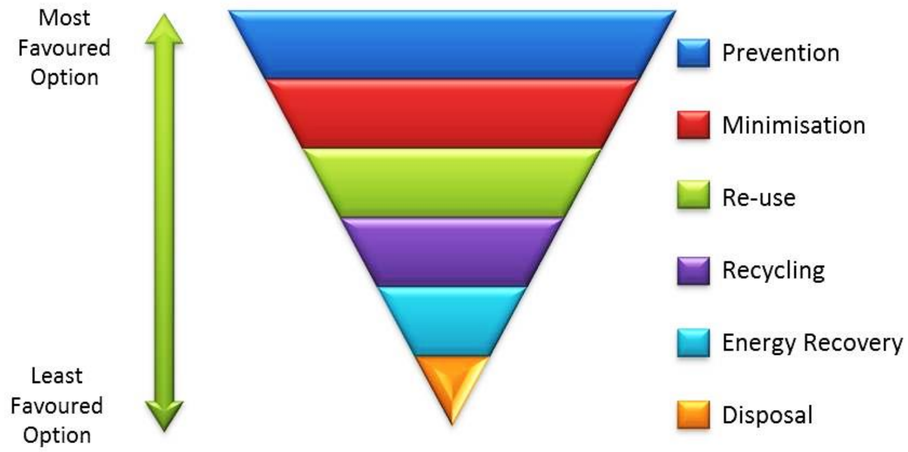


Figure 1: Waste Hierarchy

3.3. Minimum Requirements for Waste Disposal (1998)

The Minimum Requirements for Waste Disposal (1998) by Landfill forms part of the Department of Water Affairs and Forestry’s Waste Management Series. This series establishes a reference framework of standards for waste management in South Africa and serves to facilitate the enforcement of the permitting system provided for in terms of Section 20 (1) of the Environment Conservation Act (73 of 1989). This document reiterates Section 20(1) of the ECA, stating that no person or organization is allowed to establish, provide or operate any disposal site without a permit obtained from the Minister of Water Affairs and subject to the conditions contained in such a permit.

3.4. National Norms and Standards for the Assessment of Waste for Landfill Disposal[1]

The National Norms and Standards for the Assessment of Waste for Landfill Disposal prescribe the requirements for the assessment of waste prior to disposal to landfill.

[1] Published under Government Notice R635 in Government Gazette 36784 of 23 August 2013.

3.5. National Norms and Standards for Disposal of Waste to Landfill[2]

The Norms and Standards for Disposal of Waste to Landfill stipulate the waste acceptance criteria for disposal to landfill and the various waste disposal restrictions.

3.6. Waste Classification and Management Regulations[3]

The Waste Classification and Management Regulations regulate classification and management of waste to give effect to provisions of the NEMWA.

3.7. National Climate Change Response White Paper (South Africa 2011)

The National Climate Change Response White Paper identified eight Near-term Priority Flagship programmes by DEA to be implemented to address climate change. The Waste Management Flagship Programme was identified as one of the programmes that will establish the GHG (Greenhouse gas) mitigation potential of the waste management sector including, but not limited to, investigating waste-to-energy opportunities available within the solid-, semi-solid- and liquid-waste management sectors, especially the generation, capture, conversion and/ or use of methane emissions. This information will be used to develop and implement a detailed Waste-Related GHG Emission Mitigation Action Plan aimed at measurable GHG reductions aligned with any sectoral carbon budgets that may be set. This Action Plan will also detail the development and implementation of any policy, legislation and/or regulations required to facilitate the implementation of the plan.

4. Project Method

4.1. Literature Review

The following documentation was reviewed to determine the extent to which poor waste management exacerbates climate change impacts as well as modelling landfill airspace availability in cities within the context of landfilling being the main disposal method for solid waste. These documents are:

- Phase 1 State of the Waste Management Report;
- Relevant legislation; and
- Relevant literature (Refer to reference list).

4.2. Develop Waste Management Indicators

The Waste Management Indicators, refined from the Phase 1 stage of the project, have been identified as core indicators for reporting. These indicators were further investigated through a questionnaire (Refer to Annexure B) sent to the participating municipalities. The input data received from municipalities was manipulated into an excel-based model that provides the basis for the state of waste management within a city. (Refer to Annexure C).

It should be noted that privately owned sites were excluded from this study.

[2] Published under Government Notice R636 in Government Gazette 36784 of 23 August 2013
[3] Published under Government Notice R634 in Government Gazette 36784 of 23 August 2013

4.3. Municipal Interaction

Only three municipal visits were undertaken i.e. to Ekurhuleni, City of Johannesburg and City of Tshwane to collect additional information and to clarify data submitted for Phase 1 of The State of Waste Management Report. Information was gathered from the other municipalities via the questionnaire telephone calls and emails.

Note that the accuracy of waste data is questioned as a result of:

- the availability and operation of weigh bridges at various facilities;
- record keeping;
- inadequate waste recycling information;
- collection of waste by the private sector; and
- land-filling of waste at privately owned facilities.

5. Waste Management Model

Research was conducted on the current waste management practices of all participating cities. A model was developed using data of selected key indicators from participating cities. In modelling the impact of landfilling as the main method for waste disposal, the project scope required a focus on four variables:

- the number of existing licensed landfill sites in a city;
- available air space for the landfill sites;
- household growth in relation to waste generation; as well as
- economic growth in relation to waste generation.

A guideline for the use of the model is attached as Annexure D. The model is an excel spreadsheet with suitably designed formulas per indicator. The user can input data for individual indicators to gain the results per city and must follow the instructions as outlined in the table under Annexure D. The model will automatically populate and update the figures in the respective tables per city.

In the process of developing the model, the following factors that influence waste management across all the participating cities were noted. These are population; Integrated Waste Management Plans; collection and disposal of solid waste; waste generation (volumes); landfill airspace; recycling as well as waste to energy initiatives.

5.1. Population

According to the statistics in

Table 1 (in descending order of population size) CoCT has the highest population growth rate of 3.18% whilst Buffalo City only has the lowest growth rate of 0.69% indicating the urbanisation of the population to metropolitan areas. Rapid urban expansion can constrain the capacity of the cities to provide basic services to communities. The population growth can be used as a predictor for increase in waste volumes, which should then be factored into forward planning in terms of waste generation and resources in the participating cities. The various cities should therefore plan and budget accordingly.

Table 1: Population[4] of participating cities

City	Population (2011)	Number of Households (2011)	Population Growth rate (2001 – 2011, STATSSA)
City of Johannesburg	4 434 827	1 434 856	2.57%
City of Cape Town	3 740 026	1 068 573	3.18%
eThekwini	3 442 361	956 713	1.08%
Ekurhuleni	3 178 470	1 015 465	2.47%
City of Tshwane	2 921 488	911 536	3.1%
Nelson Mandela Bay	1 152 115	324 292	1.3%
Buffalo City	755 200	223 568	0.69%
Mangaung	747 431	231 921	3.1%
Msunduzi	618 462	163 993	1.12%

5.2. Waste Generation

The population of the participating cities continues to grow increasing pressure on demand for food, water and energy. This has a direct impact on the environment through people generating increasing amounts of pollution and waste. Most of this waste deposited within the existing landfill sites of participating cities show the increasing amount of waste that is being disposed of at landfill sites. Figure 2[5] below indicate waste volume trends. Greater emphasis in terms of waste management should rather be on waste avoidance and waste stream minimisation as opposed to landfilling. Data provided in this graphs is only relevant to the municipal data provided due to the fact that the private sector is reluctant to disclose any waste information.

[4] 2001 – 2011, STATSSA available at http://beta2.statssa.gov.za/

[5] The graphs cannot be of the same interval unit due to the vast difference in airspace availability between the various cities.

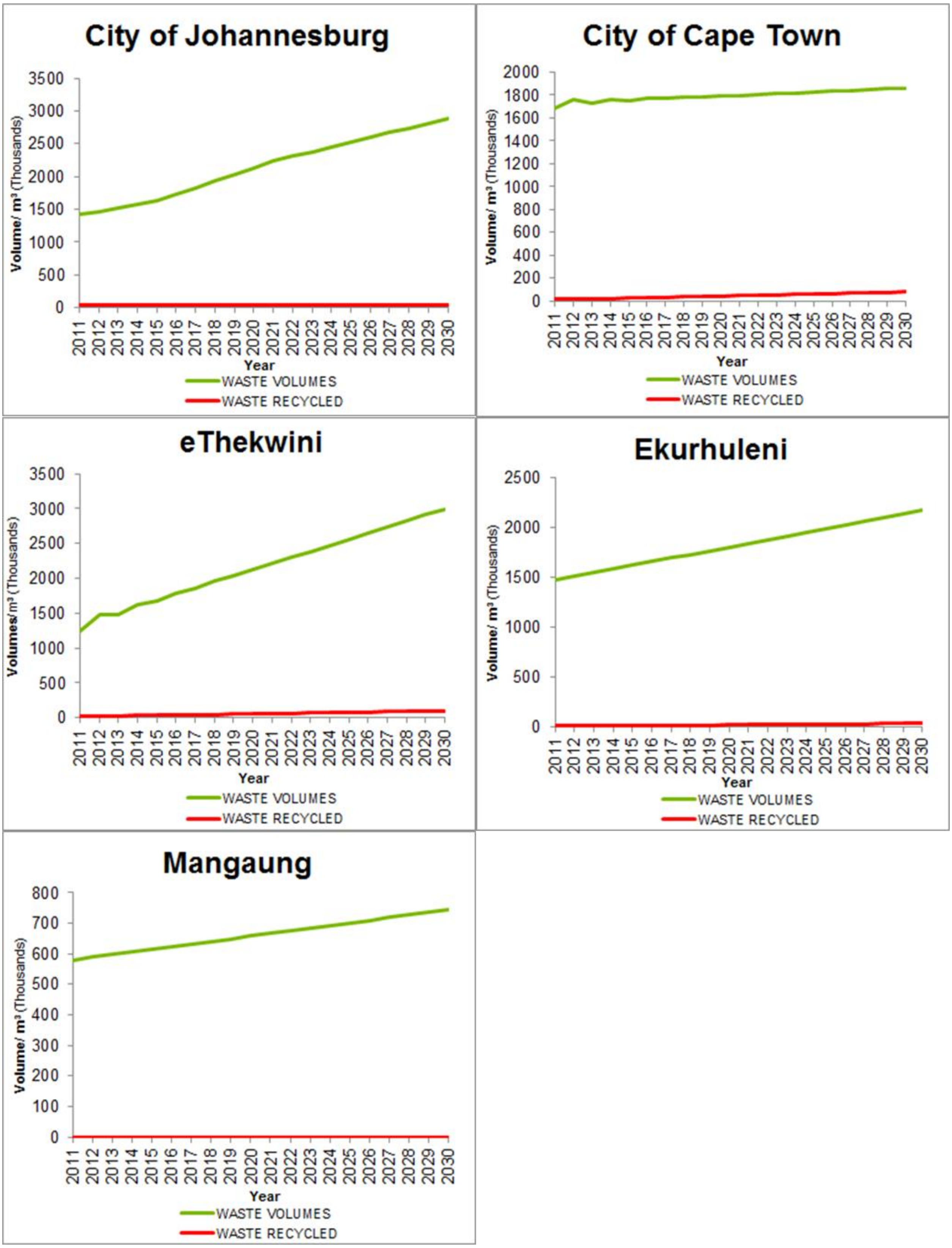


Figure 2: Projected Waste volumes disposed of at landfill sites per participating City based on the waste model[6]

[6] Annexure C: Results: State of Waste Management in Cities

5.3. Integrated Waste Management Plan

There is inconsistent development of Integrated Waste Management Plans (IWMP) across the participating cities (Table 2), comparing the status of the IWMP in 2014 and 2012 as derived from the model). Only two cities comply with the development of the IWMP i.e. existence of an IWMP that gets reviewed regularly, these cities being are CoCT and CoJ. Other cities either have an outdated IWMP or are not even in the process of developing such a plan. This has a direct impact on the ability to deliver waste management services as such cities do not have a guideline to follow in the form of an approved IWMP.

To ensure that IWMPs are prioritized with in municipalities it is necessary that these plans form part of the Integrated Development Plans. The IWMPs must be outcome focused, with priorities, objectives, targets, implementation and financing arrangements and must be realistic to the specific circumstances in each area.

Table 2: Status of IWMP in cities

City	Status of IWMP: 2012	Status of IWMP: 2014
City of Johannesburg	Draft IWMP	Council Approved in 2011
City of Cape Town	Approved	Council Approved in 2011
eThekwini	2004	Council Approved in 2004
Ekurhuleni	Unapproved IWMP	Due for Council approval in 2014
City of Tshwane	No IWMP	First draft due for Council approval in 2014
Nelson Mandela Bay	No IWMP	Draft 2013
Buffalo City	No IWMP	No IWMP
Mangaung	No IWMP	No IWMP
Msunduzi	No IWMP	No IWMP

5.4. Solid waste collection and disposal

Municipalities in South Africa are directly responsible for waste management activities including waste collection and disposal (See Table 3). The management and maintenance of waste management infrastructure (including landfill sites) is under pressure due to rapid urban expansion and increasing waste generation. Disposal of waste by landfill is the most common means of solid waste disposal in South Africa. In many cities landfill sites are reaching their full capacity and there is limited suitable land for new landfill sites. Planning and developing new landfill sites takes time and needs to meet strict legislative requirements i.e. Waste Act. Waste management initiatives have to be adopted by various municipalities across the country in line with the waste hierarchy i.e. reuse, recycling, recovery and energy generation to address this challenge to divert waste away from landfills and direct it to other waste management options.

Some of the participating cities outsourced certain waste collection services. The CoJ has the highest level of access to weekly refuse removal service with 95.3% of households having access to a waste collection service as opposed to Msunduzi with only 53.2% of their households provided with a waste collection service.

A utility/service provider acting on behalf of the various municipalities engaged in waste collection and/or waste disposal will be subject to the policies and regulations of the relevant municipality. Where there is a lack of resources to render waste management services the possibility of using Public Private Partnership solutions may be investigated.

Table 3: Access to Waste collection activities for cities in South Africa [7]

City	**Service done in-house**	**Service Outsourced**	**Weekly refuse removal service 2011, StatsSA**
City of Cape Town	X		94.3%
eThekwini	X		86.1%
City of Johannesburg		Out sourced to utility company Pikitup	95.3%
City of Tshwane	X	Certain areas outsourced to community based contractors	80.7%
Ekurhuleni	X	Certain areas outsourced to community based contractors	88.4%
Mangaung	X		78.9%
Nelson Mandela Bay	X	Certain areas outsourced to community based contractors	82.9%
Buffalo City	X		70.4%
Msunduzi	X		53.2%

Table 4 gives an indication of the number of landfill sites within participating cities as informed by municipal data and documents available as of end July 2014.

[7] Statistics South Africa available at: http://beta2.statssa.gov.za/, 13 October 2014

Table 4: Number of Landfill Sites per participating city

City	Operational city owned	Closed sites[8]	Private landfill sites	Total Landfill sites
CoCT	3 Coastal Park, Bellville South, Vissershok	27 Kraaifontein, Plumstead, Gordons Bay, Macassar, Kenilworth, Modderfontein, Athlone (2), Atlantis, Durbanville, Fish Hoek, Klipfontein, Gugulethu, Marne (2), Marina da Gama, Milnerton, Noordhoek, Pinelands, Radnor, Simonstown, Somerset west, Strand, Stranfontein, Swartklip, Witsand, Zandvliet	1 Vissershok Uitspan	31
CoJ	4 Ennerdale, Goudkoppies, Robinson Deep, Marie Louise	9 Kya Sands, Linbro Park, Soweto Mapetla, Clayville, Waterval, Honeydew, Northern Works, Genesis	2 Holfontein, FG Landfill Site	15
CoT	5 Onderstepoort, Bronkhorstspruit, Hatherley, Soshanguve, Ga-Rankuwa	10 Garstkloof, Kwaggasrand, Valhalla, Temba, Derdepoort, Eersterust, Rayton, Ekandustria, Mamelodi, Saulsville	2 Bon Accord Mooiplaats	16
Ekurhuleni	5 Rooikraal, Platkop, Weltevreden, Simmer and Jack, Rietfontein	12 Nigel, Sebenza, Chloorkop, Bullfrog pan, Wadeville, Alberton, Deep levels, Southern dumping, Brakfontein, Tembisa, Zesfontein, Verwoerdpark	1 Chloorkop	18

[8] Informed by: Department: Environmental Affairs And Tourism, Disposal Site Census Report Of Unauthorised Disposal Sites In South Africa, Report No: 227870/PW0, Volume 1

City	Operational city owned	Closed sites[8]	Private landfill sites	Total Landfill sites
BCMM	2 Second Creek, King Williamstown	1 Ducats	0	3
eThekwini	4 Bisasar Road, Marianhill, Buffelsdraai, Lovu (new)	7 St Lucia, Bulbul Drive, Ulazi, Ntuzuma, Madadeni, Osizweni, Hammersdale	1 Shongweni,	12
Msunduzi	1 New England	0	0	1
Mangaung	3 North, South, Botshabelo	1 Thaba Nchu	0	4
NMBMM	3 Arlington, Koedoeskloof, Aloes	1 Kwanobuhle	0	4

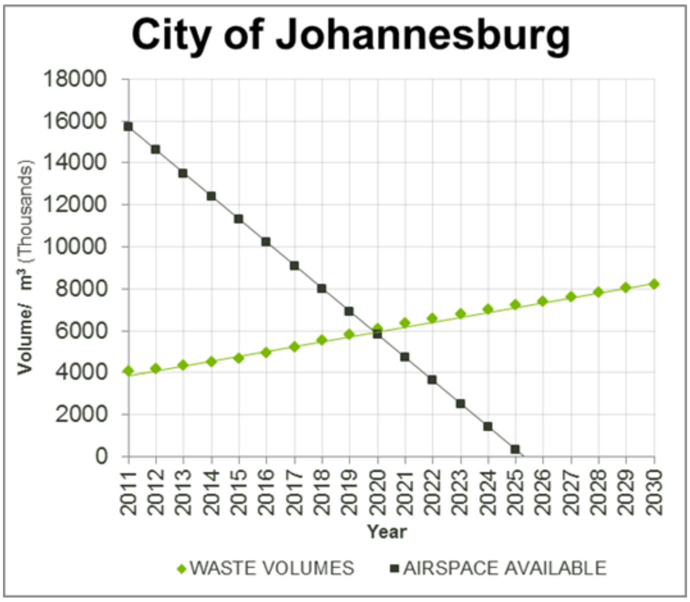
5.5. Availability of Landfill Airspace

Landfill airspace[9] can be defined as the volume of space on a landfill site which is permitted for the disposal of solid waste. This space is initially occupied by air which will eventually be consumed by the disposed waste, therefore referred to as “landfill airspace”.

The modelling of landfilling vs available airspace could only be done for six participating cities ie. CoJ, CoCT, eThekwini, CoT, EMM and MMM due to limited data availability. A concern regarding landfill sites in the cities is the available airspace to deal with the increasing waste volumes. Accurate figures on available landfill airspace and waste volumes are not readily available however assumptions are made based on available data[10] as shown in Table 5[11].

5.5.1. Cities with airspace depletion before 2030

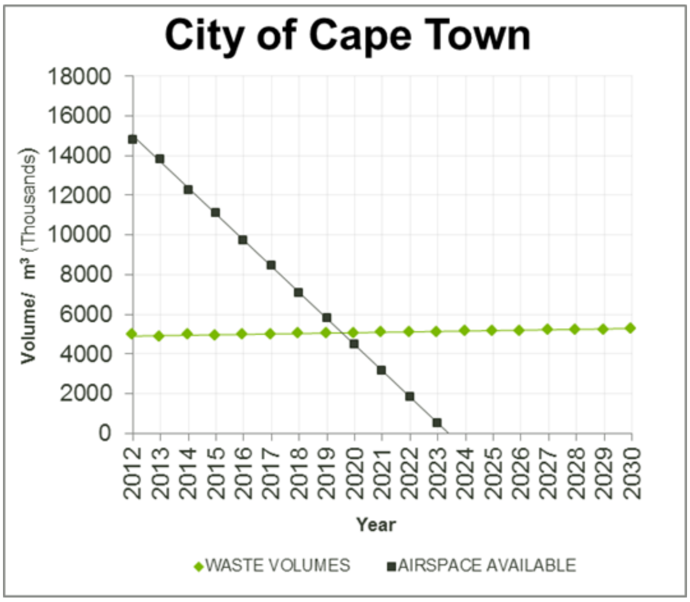
Table 5: Waste Volumes vs Airspace available at landfill sites[12] per participating City[13]

City	Interpretation
	The waste tonnages extrapolated from the model are in direct relation to population trends within CoJ based on projected generation rates. The graph indicates that airspace within CoJ will diminish within the modelled time period by the year 2025. This result is consistent with the recorded population growth for the city as well as anticipated future growth due to urbanization. The rate at which the airspace diminishes can be reduced in the city if greater efforts are made to divert waste from landfill to other uses (reducing, reusing, recycling etc.). Population is growing steadily and this can be attributed to factors e.g. urbanisation, influx from people from surrounding provinces. CoJ is the economic hub of South Africa and there are profile changes in the socio economic levels. Most of the waste facilities are located in the southern regions and this creates challenges for the treatment and disposal of waste in the northern regions of CoJ. As a result large amounts of waste are being transported across the city. The Northern part of CoJ is highly economically active producing various waste streams due to development. With the absence of waste facilities in the Northern region waste is being diverted to private waste facilities. Adequate planning and the timing of developing

[9] https://swana.org/Products/ProductDetail.aspx?pc=ARF05LFAIR
[10] Operational landfill sites
[11] Graphs are indicated in different measures due to huge difference of available airspace per landfill site as per model

[12] It should be noted that privately owned landfill sites were excluded from this study due to non-disclosure of information.

[13] Projected from actual data per city as per developed model (Refer to Annexure C)

<table>
<tr><th>City</th><th>Interpretation</th></tr>
<tr><td></td><td>new waste infrastructure and alternative waste treatment facilities have not been forthcoming. This has resulted in the current limited landfill airspace availability.</td></tr>
<tr><td>
</td><td> The CoCT is the only city that faces depletion of its airspace halfway through 2030. Based on generation rates and current waste tonnages, the graph indicates that airspace within CoCT will deplete by 2023. There are currently active programs for waste separation and recycling in the metro and this is contributing towards the savings in airspace to some degree. There are strategic plans in place to manage the landfill infrastructure requirements for the future and efforts towards private partners involved as well. The development of further MRFs and alternative waste technologies will need to be broadly assessed to provide an adequate solution. The waste generation volumes are relative however the timelines for new facilities need to be addressed sooner. </td></tr>
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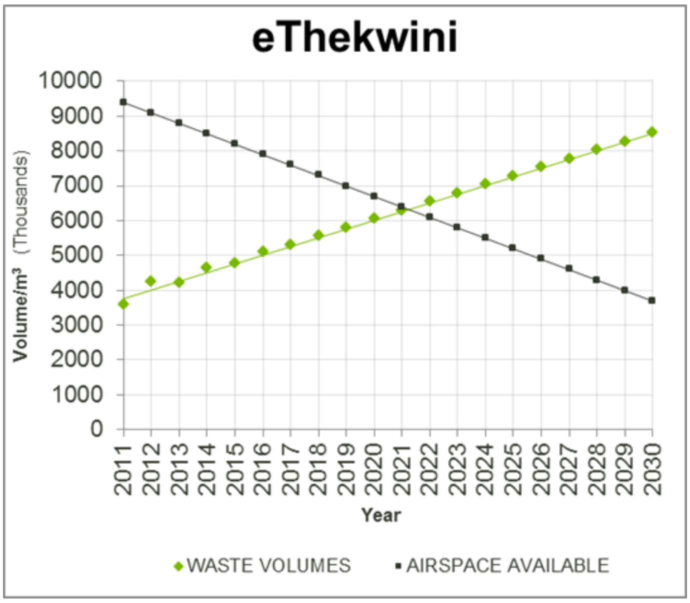
5.5.2. Cities with available airspace after 2030

<table>
<tr><th>City</th><th>Interpretation</th></tr>
<tr><td>
</td><td> Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within eThekwini. The model and adjacent graph indicates that airspace within eThekwini will be 3.7 million m^3 as of the year 2030. Due to an increase in waste generation from 2021, the model also indicates that waste will be produced above airspace available. There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. The metro has effective waste collection systems and does take steps to educate communities on recycling and engages with the greater public on recycling and reduction programs. With the continued growth in the city, the metro is continuously planning for landfill airspace and is also planning for a new mega landfill to the west of the city. The pro-active steps must continue to evolve and the process towards reducing waste to landfill should be a priority on the planning schedule. </td></tr>
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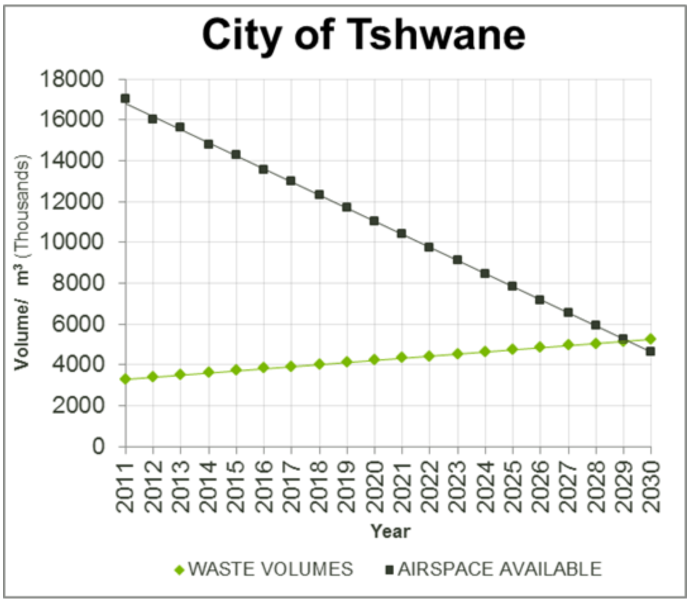
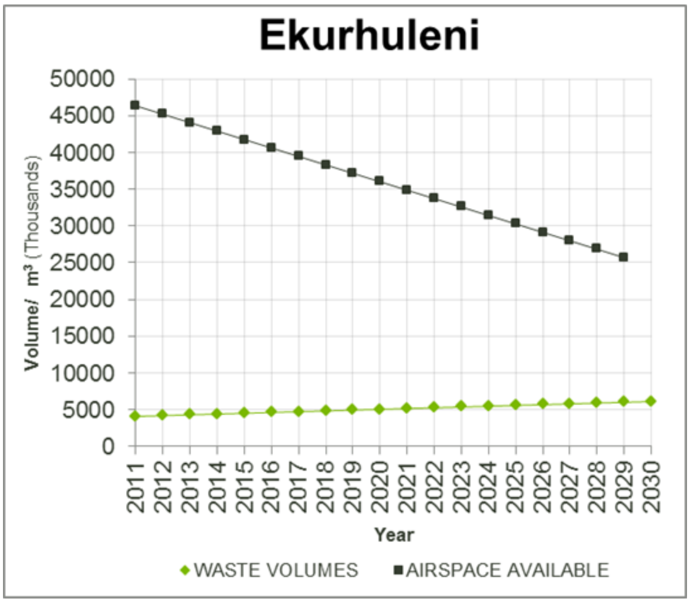
<tr><th>City</th><th>Interpretation</th></tr>
<tr><td>
</td><td>Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within CoT. The model and adjacent graph indicates that airspace within City of Tshwane will be 36 million m^3 as of the year 2030. Due to an increase in waste generation from 2029, the model also indicates that waste will be produced above airspace available.

There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. The graph depicts a situation of immediate intervention to call upon expertise to render technical support and the development of a waste reduction strategy to landfill which will outline immediate and long term planning. As a key metro and with continued growth, the existing landfills and the infrastructure are going to come under extreme pressure. The lack of appropriate skills and introducing suitable disposal methods are negatively impacting on the available airspace. Planning for new integrated waste facilities need to be initiated now to manage the situation.</td></tr>
<tr><td>
</td><td>Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within Ekurhuleni. The model and adjacent graph indicates that airspace within Ekurhuleni will be 25 million m^3 as of the year 2030.

There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. One of the key challenges in the metro is that all of the existing landfills are on the outskirts of the metro and none in the high density or high income areas. The challenge is the logistics and distances to travel which creates its own impacts. The growth of the informal areas and natural progression of these communities into different economic classes will progressively develop different waste streams resulting in large waste volumes leading to the metro being forced to consider alternatives. Reclaimers do exist on some of the landfills and with their involvement on the landfill it can be seen some of the waste streams are being recovered for recycling. Key going forward is for an implementation plan for waste minimization and a phased plan for reduced waste to landfill in conjunction with considering other technologies.</td></tr>
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<tr><th>City</th><th>Interpretation</th></tr>
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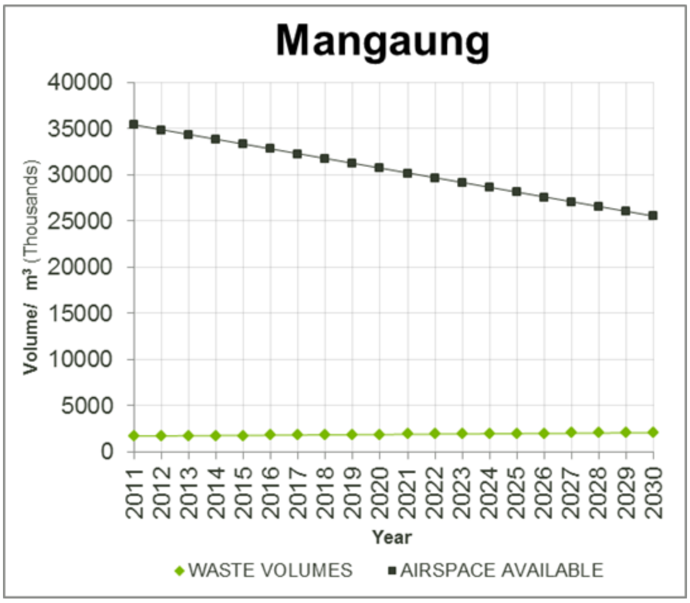

</td><td>
Based on projected generation rates, the waste tonnages extrapolated from the model are in direct relation to population trends within Mangaung. The model and adjacent graph indicates that airspace within Mangaung will be 25 million m^3 as of the year 2030.
There will be increased airspace available in the municipality if greater efforts are made to enforce the waste hierarchy. The city has 3 large landfills however the current deposition methods and operational standards are not sustainable for long term landfill availability. The lack of sufficient resources and support in the waste department contributes to the existing problem. Further to this, the presence of reclaimers on the landfills poses a challenge in terms of risk and health issues. With the reclaimers on the landfills, they are undertaking their own scavenging of materials and creating a bigger challenge for the metro in managing the disposal process. There is no recycling happening in the formal sense and as a result the airspace is being rapidly being utilized. Waste streams such as builders rubble is mixed in large quantities with municipal waste. There is a real opportunity to introduce separation, recycling and composting at household and landfill levels.
</td></tr>
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5.6. Waste Recycled

Large amounts of recyclables such as plastic, metal, glass cardboard and paper are landfilled each year which is a contributing factor to the decreasing airspace at landfill sites across the country. Only when material is deemed non-useful, should it be treated and the remnants disposed of in an appropriate manner. The majority of recycling is happening at the landfill sites (not at source) and the recyclables are sourced by reclaimers as large quantities of recyclable materials are mixed with waste arriving at landfill sites. Informal recycling on the landfill sites is widespread across South Africa and has health and safety implications for the reclaimers. It must be noted that reclaiming and removal of high value waste streams from landfills/transfer stations can make it unfeasible for municipalities to recycle due to recovering of costs for i.e. infrastructure, equipment, human resources, marketing etc.

As recycling is listed near the top of the waste hierarchy, the participating cities must ensure that the waste hierarchy is enforced within each municipality, to reduce the amount of waste disposed of at landfill sites i.e. waste separation at source Benefits of waste recycling is not only limited to the reducing the impact on the environment, but includes benefits related to economic, social and aesthetic aspects (See Figure 3). Some advantages of recycling can:

- Protect the environment;
- Reduce energy consumption;
- Reduce pollution;
- Reduce global warming;
- Sustainable use of resources;

- Conserve natural resources;
- Reduce amount of waste to landfills; or
- Create green jobs

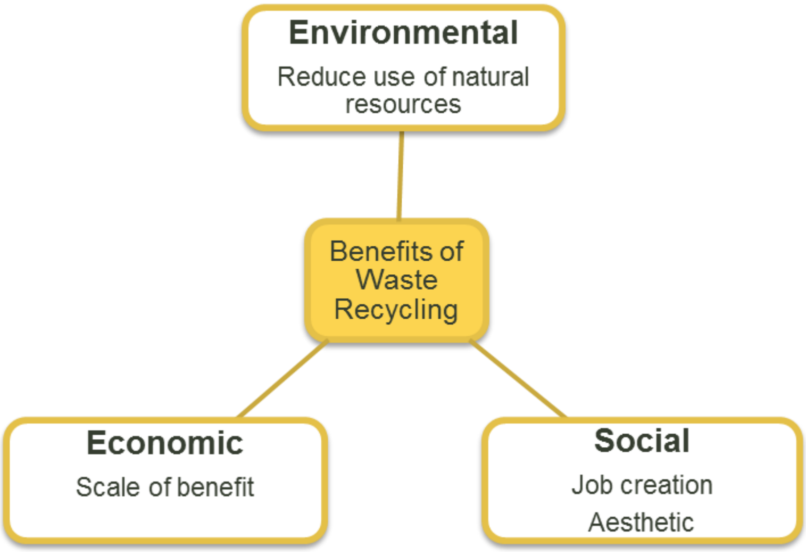

Figure 3: Benefits of waste recycling

Less than 2% on average of waste is recycled at the participating cities (Refer to **Error! Reference source ot found.** to **Error! Reference source not found.**[14]). The same figures depict different categories of waste recycled at three (3) of the participating cities where waste recycling information was received and assessed. The waste recycled per category from the other cities was either not made available at the time of this study or did not seem realistic, i.e. City of Tshwane indicated that 25% of their waste is recycled. There was no accurate weighbridge data to evaluate waste types entering landfill, therefore no means of knowing the quantities and frequencies of each waste stream, thus no effective recycling planning. A comparative analysis with the remaining 6 participating cities could therefore not be made.

[14] Data as provided by the Cities as an average per year

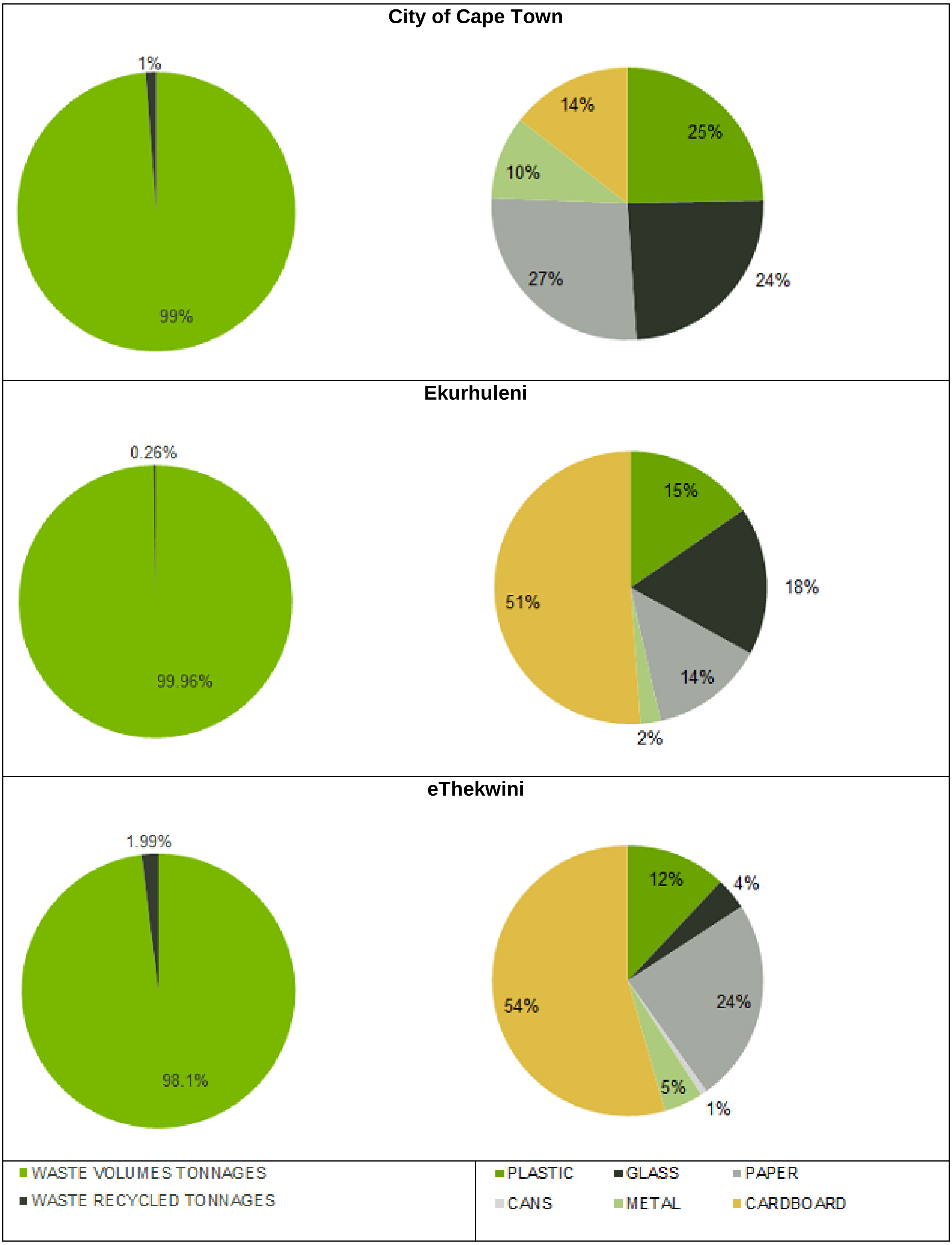

Figure 4: Recycling figures in various participating cities

From the graphs above, it can be noted that CoCT recycles on average 1.21%, eThekwini 1.99% and Ekurhuleni 0.26 % of the total tonnages of waste generated. CoCT has a different profile of recycling in comparison to the other cities; this may be due to the following factors that are implemented by CoCT:

- The City has a defined waste minimisation strategy.
- Recycling initiatives are outsourced to contractors.
- City has an established MRF (Kraaifontein).
- By-laws and policies are clear on recycling.

Although this amount of recycling seems low it is not considered a true reflection of the efforts of these cities as there are still gaps in the data management. It should be noted that this figure excludes private recycling initiatives as the private sector is reluctant to disclose any data. Metropolitan municipalities globally are more successful in achieving higher recycling volumes as they have access to adequate funding and resources. They are in a position to allocate funds to education and awareness campaigns.

5.7. Waste to Energy

Conversion of waste to energy falls low in the hierarchy of waste management. It is less preferred in comparison to “reduce, reuse and recycle” because it does not impact on the volume of waste generated or reduce the pressure on the landfill. Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel. Using energy recovery to convert non-recyclable waste materials into electricity and heat, generates a renewable energy source and can reduce carbon emissions by offsetting the need for energy from fossil sources as well as reduce methane generation from landfills.

A number of waste to energy (WtE) projects have been initiated (

Table 6) in the cities where eThekwini is the front runner generating 1.1MW and 6.5MW electricity harnessing the power from Landfill gas (LFG) at Marianhill and Bissasar Road landfill sites respectively. Benefits of LFG projects are as follows:

- Reduction of emissions of greenhouse gases that contribute to global climate change.
- Offsetting the use of non-renewable resources, such as coal, oil, and natural gas.
- Improving air quality.
- Providing revenue for landfills and energy cost savings for users of LFG energy.
- Creating jobs and economic benefits for communities and businesses.

Table 6: Status of waste to energy projects in cities

City	WtE projects
City of Cape Town	Design phase of landfill gas project at Coastal Park landfill site
eThekwini	1.1MW and 6.5MW electricity at Marianhill and Bissasar Road landfill sites respectively
City of Johannesburg	Design phase of landfill gas project with gas wells installed at Robinson Deep and Marie Louise landfill sites. Gas is currently being flared while the City waits for IPP status approval.

City	WtE projects
City of Tshwane	Feasibility study underway
Ekurhuleni	Landfill Gas flared at 4 landfill sites, Rooikraal, Platkop, Rietfontein and Weltevreden landfill sites
Mangaung	No information available
Nelson Mandela Bay	Landfill gas project designed for Arlington and Koedoeskloof landfill sites
Buffalo City	Landfill gas flared at Second Creek landfill site
Msunduzi	No information available

Although South African cities are only exploiting LFG energy for solid waste, other WtE processes should also be investigated e.g. combustion, gasification, pyrolyzation, biogas (for electricity and fuel) and anaerobic digestion. Benefits from WtE processes are:

- Electricity and heat can be generated from waste which provide an alternative and more environment-friendly source of energy
- Waste that would have normally gone to landfills is diverted to an energy processing unit thereby saving valuable land.
- The cost associated with the transport of wastes to landfill is reduced and also landfill taxes imposed by governing bodies are avoided.
- The by-product of some waste to energy processes such as anaerobic digestion can be used as fertilizers and improves the nutrient content of soil.
- When waste is delivered to a waste to energy facility, the methane that would have been generated if it were sent to a landfill is avoided
- Generating energy from waste, the carbon emission that would have been generated from a fossil fuel source is avoided.
- Waste to energy plants are generally setup locally it creates jobs, the local community benefits and materials are sourced locally.
- Using of waste to generate electricity can assist in the shortages.

Waste characterisation is a critical factor in determining WtE projects. Waste characterisation is the process by which the composition of different waste streams is analysed. Waste characterisation plays an important part in any treatment of waste which may occur. Developers of new waste technologies must take into account the exact composition of waste streams in order to fully treat the waste. It can be concluded that participating cities can achieve increased waste reduction in terms of implementing WtE projects.

6. Climate Change

Climate change, widely accepted to be driven by anthropogenic sources of greenhouse gases, is one of the key challenges faced by society in the 21st century. As such, it is critical that the effects of climate change from different activities are well understood and acted upon to ensure that we mitigate greenhouse gas (GHG) emissions in the most effective and economic way possible, see Figure 5.

A rise of only a few degrees in the Earth's average temperature could result in:

- More frequent and intense storms
- Flooding of beaches, bay marshes, and other low-lying coastal areas
- More precipitation in some areas and not enough in others
- Wider distribution of certain infectious diseases

The waste sector is estimated to be responsible for approximately 1 to 5%[15] of global GHG emissions. These emissions are mainly associated with the generation of carbon dioxide and methane gas from waste disposal and landfilling of organic waste as well as from the combustion of waste. It must be noted that the generation of carbon dioxide from the combustion of biodegradable waste is not generally considered to contribute to a net increase in atmospheric carbon dioxide levels as it is viewed as 'short cycle carbon'. The generation of methane from landfills is of particular concern as methane is twenty three times more powerful than carbon dioxide as a GHG.

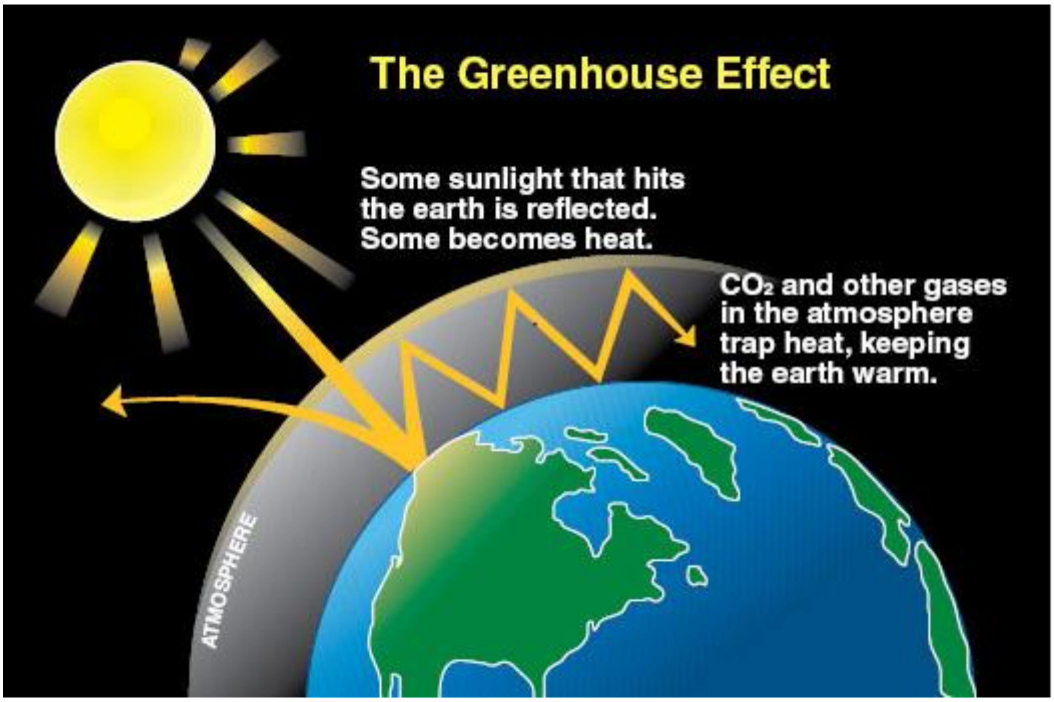

Figure 5: Green House effect[16]

As well as generating GHG, the participating cities have the potential to play an important role in reducing GHG emissions. For example:

- Generation of renewable energy from waste replaces the energy generation from fossil fuels ('long-cycle carbon'),

[15] http://epa.gov/climatechange/climate-change-waste/
[16] http://www.ecy.wa.gov/climatechange/whatis.htm

- Materials recycling avoid the greenhouse gas impacts associated with the mining of raw materials and conversion into basic materials for recycling, particularly for materials such as aluminium and glass.
- Treating waste closer to its source reduces the greenhouse gas emissions associated with the transport of waste materials.

In this context, it is important that the carbon impacts of waste management activities are measured and monitored so as to allow effective and robust decisions to be made regarding different waste management routes. Using appropriate metrics for the GHG impacts of different waste management options will allow carbon impacts to be tracked and maximise the potential for the efficient reduction of the sector's greenhouse gas emissions.

Waste generation in general does not have a positive impact on the climate. Waste treatment and disposal can have both positive and negative impacts on climate. Waste management activities should be reengineered to reduce GHG emissions.

GHG emissions and savings (credits) are attributable to various stages of a waste management system. Figure 6 shows a simplified schematic of a municipal waste management system with the predominant climate impact sources. Waste Management activities, collection, separation, treatment, transfer and disposal applies to all waste types. The transfer of waste from transfer and treatment facilities will also have an effect on climate change.

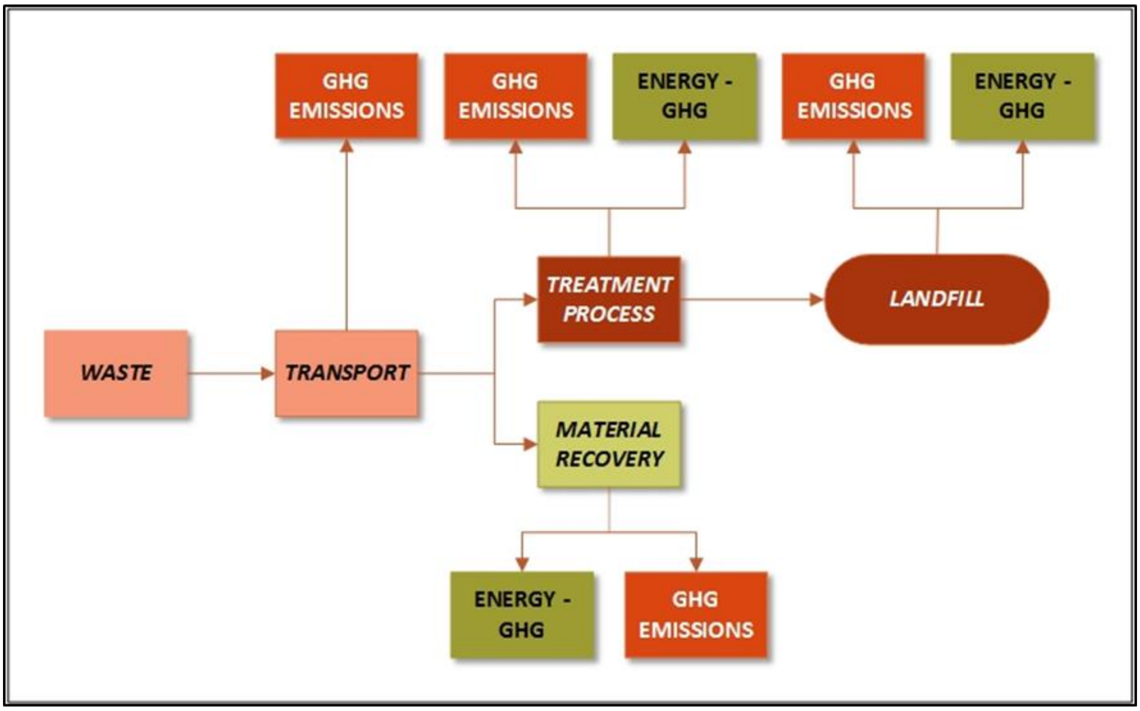

Figure 6: Schematic of waste management system and GHG emissions[17]

The participating cities can reduce GHG emissions through several activities and generate a net GHG benefit through waste avoidance, material recovery, and energy recovery by:

- Avoiding the use of primary materials for manufacturing through waste avoidance and material recovery;

[17] Waste and Climate Change: Global Trends and Strategy Framework, United Nations Environmental Programme, July 2010

- Producing energy that substitutes or replaces energy derived from fossil fuels (i.e. the emissions arising from the use of waste as a source of energy);
- Storing carbon in landfills (i.e. carbon-rich materials that are high in anaerobic landfill conditions, such as plastics and wood) and through application of compost to soils;
- Education and awareness;
- Policies;
- Interventions and Identification of gaps;
- Technology assessment;
- Available resources within the Cities;
- Grow "Green Economy";
- Capacity building; and
- Resources.

6.1. Sustainability

Waste disposal in landfill sites has an impact on acquiring land to be dedicated only to landfilling of waste. Landfill sites can eventually be rehabilitated and used for limited human activities or nature conservation purposes; however, this is a lengthy and expensive process. Disposing of waste in landfills removes a considerable quantity of useful products from general circulation. Large amounts of plastic, metal, glass and paper are landfilled each year; many of these products could be recycled, thereby reducing the need for the further consumption of raw materials required for the creation of new products. Local authorities are often unable to introduce integrated waste management systems due to the associated high costs. Very few models are capable of financing themselves while operating effectively.

- Sustainable waste management and recycling systems should aim to reduce the quantity of natural resources consumed, while ensuring that any resources already taken from nature are reused multiple times, and that the amount of waste produced is kept to a minimum. The processing of waste plays a key part in this process.

Households and businesses should be encouraged to improve their environmental efficiencies by eliminating waste through resource recovery practices, which are sustainability-related activities. One way to do this is a shift away from waste management to resource recovery practices by recycling materials such as glass, food scraps (composting), paper and cardboard, plastic bottles and metal. Table 7 summarizes the source types linked to the waste management activities.

Table 7: Source types linked to the waste management activities

Waste Management Activity	**Direct Emissions**		**Indirect Emissions**	**Avoided Emissions**	**Emission Reducing Actions**
	Gross Emissions	**Net Emissions**			
Collection and Transportation	CO_2 from fuels consumption	CO_2 from fuels consumption	CO_2 from outsourced transport		Use of electric vehicles Uses of alternative fuels Development of alternative means of transportation
Transfer	CO_2 from on-	CO_2 from on-	CO_2 from		Actions done to

Waste Management Activity	Direct Emissions		Indirect Emissions	Avoided Emissions	Emission Reducing Actions
	Gross Emissions	**Net Emissions**			
	site fuels consumption	site fuels consumption	electricity consumption		improve energy efficiency of equipment and facilities
Sorting, recycling and recovering	CO_2 from on-site fuels consumption	CO_2 from on-site fuels consumption	CO_2 from electricity consumption	Avoided GHG corresponding to the emissions resulting from the production of an equivalent quantity of materials CO_2 avoided through potential production of solid recovered fuels	Actions done to improve sorting rate before selective sorting Recovery of sorting rejects
Landfill	CH_4 from landfill gas CO_2 from landfill gas CO_2 from on-site fuel consumption	CH_4 from landfill gas CO_2 from on-site fuel consumption	CO_2 from electricity consumption	CO_2 avoided through energy production	Optimization of CH_4 oxidation, capture and combustion Optimization of energy recovery

6.1.1 Waste reduction

Waste prevention and recycling can be referred to as waste reduction which assists in managing waste we generate. The benefits from waste reduction:

- **Reduction in emissions from energy consumption due to recycling.** Manufacturing goods from recycled materials requires less energy than producing goods from virgin materials.
- **Less carbon dioxide is emitted to the atmosphere by preventing waste (Waste prevention).** When people reuse things or when products are made with less material, less energy is needed to extract, transport, and process raw materials and to manufacture products.
- **Reduce methane emissions from landfills.** Waste prevention and recycling (including composting) divert organic wastes from landfills, reducing the methane released when these materials decompose.

6.1.2 Composting

Recoverable materials that are organic in nature, such as plant material, food scraps, and paper products, can be recovered through composting and digestion processes to decompose the organic matter. Composting systems treat biodegradable material to produce organic soil amendment products that can replace fertilisers and/or peat, reduce the need for pesticides, improve soil structure, reduce erosion, and reduce the need for irrigation. Composting of source-separated wastes requires significant investment in local community education (both households and commercial enterprises) and public awareness.

Simple composting systems are an effective solution to reduce waste quantities and generate a valuable compost product for application to agriculture.

Calculations for estimating emissions from decomposition of waste in landfill are subject to high levels of uncertainty; it is therefore difficult to gauge the accuracy of current estimates of the climate impact of waste activities, due to data limitations. Results of projections of GHG emissions from waste are dependent on the assumed rates of waste generation.

During landfilling or composting, the organic matter contained in organic and garden waste decomposes and part of its carbon is emitted as CO_2 and/or CH_4, back to the atmosphere. See Figure 7 for the evolution of stored organic matter.

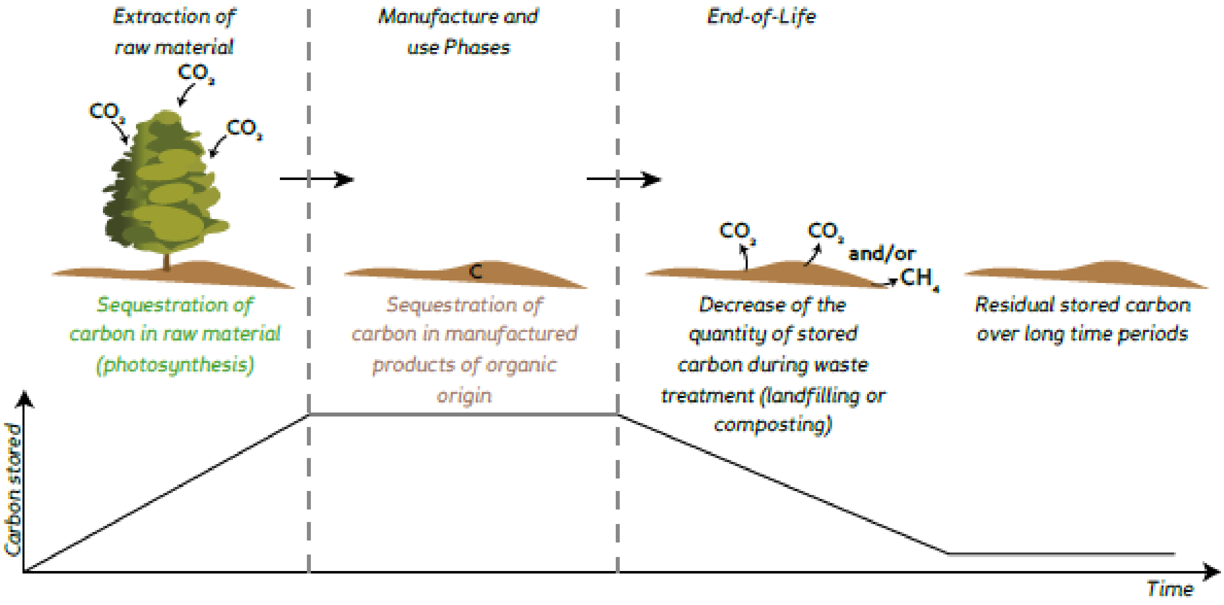

Figure 7: Evolution of stored organic carbon versus time[18]

6.1.3 Landfill Gas

Methane emissions from landfill are the major source of climate impact in waste management. Waste contains organic material, such as food, paper, wood, and garden trimmings. Once waste is deposited in a landfill, microbes begin to consume the carbon in organic material, which causes decomposition. Under the anaerobic conditions prevalent in landfills, the microbial communities contain methane-producing bacteria. As the microbes decompose organic material, methane (approximately 50%), carbon dioxide (CO_2) (approximately 50%), and other trace amounts of gaseous compounds (< 1%) are generated and form landfill gas. In controlled sanitary landfill sites, the process of burying waste and regularly covering deposits creates an internal environment that favours methane-producing bacteria. This decay of the carbon stock generates emissions even after waste disposal has ceased. Methane and carbon dioxide (CO_2) are GHG whose presence in the atmosphere contribute to global warming and climate change

[18] Protocol for the quantification of greenhouse gases emissions from waste management activities, Entreprises pour l'Environment (2008)

Calculations for estimating emissions from decomposition of waste in landfill are subject to high levels of uncertainty. It is difficult to gauge the accuracy of current estimates of the climate impact of waste activities, due to data limitations. Results of projections of GHG emissions from waste are dependent on the assumed rates of waste generation.

Figure 8 shows the different emission sources within a landfill site (source: EAA 2005):

- A : landfill gas oxidized within the cover layer and diffused in the atmosphere – CO_2 only
- B : landfill gas diffusion in the atmosphere – CO_2 and CH_4
- C : leak in the landfill gas collection system – CO_2 and CH_4
- D : landfill gas flared or combusted in a turbine or a boiler – CO_2 only

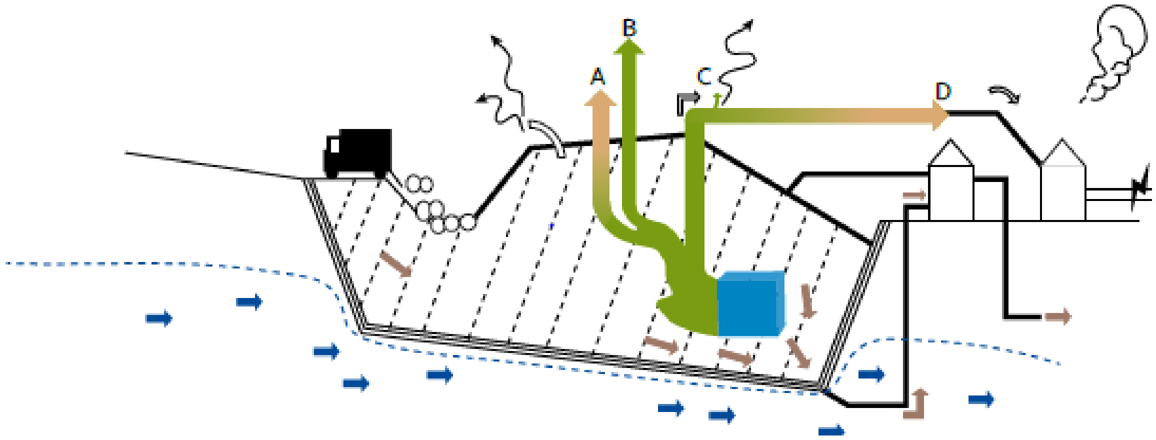

Figure 8: Emission sources within a landfill site[19]

6.1.4 Best Practice: Landfill Operations

Literature[20] confirms that the types of waste or characterization of the waste has a large influence on the utilisation of the airspace for the landfills, similarly the aspects of urbanisation and population growth. The size of permitted footprints for landfilling and the number of landfills are also contributing factors. The operational aspects and the manner in which the site is operated and developed will play a role in the utilisation of airspace and the factors for this include:

- Cover application
  - Comply with frequency and thickness in terms of waste licence and relevant legislation. At the end of each operating day, active landfill sites must be covered with at least 6 inches[21]
  - (15.2 cm) of soil to control disease vectors, fires, odours, windblown litter and scavenging by animals.
- Compaction densities
  - Establish if the correct number of passes with the compactor is achieved.
  - Consider if the right size compactor being used for the specific operation
  - Are dozers or front end loaders being used as opposed to compactors? Landfill compactors should be used as they have specific purpose built use for compacting waste at a specific pass and compaction ratio. Dozers are only meant to "push and level" waste and not compact waste which results in unnecessary airspace depletion.

[19] Protocol for the quantification of greenhouse gases emissions from waste management activities, Entreprises pour l'Environment
[20] http://www.epa.gov/osw/conserve/tools/recmeas/docs/guide_b.pdf
[21] Waste Management practices, municipal, hazardous and Industrial, John Pichtel

- Poor disposal planning
    - No provision is made for wet cell design and operation on some of the landfill sites.
    - Inadequate provision for separate garden and builders rubble disposing areas.
    - No operational plans available on the landfill sites indicating the filling of cells.
- No reliable monthly surveys
    - No accurate data to evaluate airspace consumption monthly which impacts on operational planning.
- No operational weighbridges
- No defined tonnage information to calculate waste entering landfill thus no reliable information on waste trends can be concluded.

The primary means of effective landfill airspace management is:

- Effective compaction of waste placed will reduce waste volume and therefore minimise the airspace consumed provided that no bulky waste or tyres are repeatedly disposed of into the landfill thereby consuming airspace.
- Apply correct cover to waste ratio, as too much cover can consume air space.
- Diversion of waste streams to a material recycling facility (MRF) to be sorted and the valuables recyclables extracted and only the remaining waste disposed of at the landfill sites.
- Bulky waste e.g. white goods should be redirected to an electronic reclaiming company.
- By diverting Green waste to a composting facility, it offers the advantage of saving landfill airspace as it is a bulk consumer of airspace.
- Long term planning for cell development.

6.1.5 Overview of a carbon metric approach

A simple carbon accounting approach quantifies the direct carbon emissions from a given activity. For example, the combustion of waste generates carbon dioxide, the mass of which can be quantified if sufficient information is known about the composition of the waste and the combustion conditions. The limitation of this approach is that it does not capture the carbon emissions generated by other stages in a material's life (e.g. raw materials production, retail, etc.). In many cases, the GHG emissions of these other stages of a material's life are far larger in magnitude than the GHG emissions generated by a material's treatment or disposal once it becomes a waste. Measuring direct emissions also fails to capture the reductions in GHGs achieved by recycling the material or using it to generate energy.

A 'carbon metric' approach seeks to capture these other indirect GHG impacts by quantifying the GHG emissions of other stages in a material's life, such as raw materials extraction and the use of a product. This approach requires a methodical and detailed analysis of each component of a material's life from its production, through to its disposal. In undertaking this 'life cycle assessment' (LCA), it is essential to clearly define the system boundary i.e. the elements of a material's life that are captured by the metric.

The approach that has been applied to generate the metrics presented below reflects the carbon emissions associated the following stages:

- Extraction of raw materials,
- Manufacture,
- Distribution
- Disposal (including the GHG savings associated with reuse or recycling of a material).

Note that the approach applied here does not include emissions associated with the retail and use of a product.

Whilst the use of a carbon metric approach does provide a much better reflection of the GHG emissions for a material, it does have limitations. The metric itself is based on many simplifying assumptions regarding the GHG emissions at each stage of its lifecycle so is itself a simplifying, indicative value.

The metrics presented here are based on the Scottish Government's carbon metric system. These metrics represent the most comprehensive set of carbon metrics for use in the context of waste management options. However, they are based on various factors which are specific to Scotland and, as such, should be used with caution. Whilst many of the characteristics of the waste of urban South Africa will be similar to a Scottish context, there will be a number of factors that are significantly different and, as a result, will have an effect on the GHG emissions associated with a particular material and its management as a waste. For example:

- The energy mix (i.e. the proportion of electricity generated by oil, gas, coal and renewable sources) will be different. This variation will affect the estimated carbon savings associated with the generation of energy from waste (for example, by anaerobic digestion or incineration with energy generation).
- The emissions and savings associated with the recycling of materials may be different due to the location of appropriate reprocessing industries for different materials, a factor which will affect the energy balance associated with materials recovery as well as the impact6s associated with the transport of materials.

The landfills in Scotland are regulated under the EU Landfill Directive and, as such, must meet very specific requirements in engineering terms which, in turn, will determine the typical levels of gas recovery, leachate egress, etc. Clearly, South African landfills are regulated under different regulations and, in particular, landfill gas recovery is not widespread. As a result, the estimated greenhouse gas impact of South African landfills may well be underestimated by these metrics. It should be noted that the South African cities should initiate an application to the Department of Energy to function as an Independent Power Producer (IPP), this may be difficult as Eskom and DoE do not want municipalities to become electricity providers. A summary of the metrics is presented in Table 8. These are in effect conversion factors. Each metric represents the nominal greenhouse gas emissions associated with one tonne of waste managed through each disposal route. So, for example, one tonne of general household waste which is landfilled is assumed to generate 3,411 tonnes of carbon dioxide equivalent. Should recycling, composting or anaerobically digestion of this household waste take place will be reduced by 845 tonnes of carbon dioxide equivalent.

Table 8: Summary of carbon metrics by waste stream (kg Co2 equivalent per tonne of material)

Waste stream/material	**Net carbon impact**		
	Landfill[22]	**Recycled, composted or anaerobically digested**	**Reduced**
Household and similar wastes	3,411	2,566[23]	845
Animal & mixed food wastes	3,847	3,535[24]	312
Garden waste[25]	214	-46	260

[22] Assumes 75% of landfill gas is captured for energy generation (at a 46% conversion rate).
[23] Assumes recycling of recyclable fractions of household waste stream
[24] Assumes energy recovery with, based on an energy conversion efficiency of 23% incineration
[25] Assumed to be equivalent to vegetal wastes and assumes 100% composting.

7. Gap analysis

Gaps exist in the current range of activities in the field of waste and climate change in the cities. However, it is also apparent that perhaps the most significant 'gap' is a cohesive, systematic approach to the global mobilisation of waste and climate change programmes. The magnitude of the climate impact from waste management is largely guesswork – essential information regarding waste generation and management is simply not available or is insufficient. Even more important is the lack of waste information that would allow a more accurate assessment of the opportunities. In the waste sector, opportunities generally equate to net GHG savings.

Without a clear idea of the problem and opportunities in each city, waste strategies and action plans cannot be realistically developed. And without strategies, assistance will necessarily be fragmented, potentially resulting in poorly allocated resources, lack of government support and commitment, and duplication. Fact-based strategies, including clear goals and targets, are critical to guide strategies.

The benefits of waste prevention, in terms of the potential to off-set GHG emissions, have not been fully explored or exploited at the cities level. Further investigations for specific materials are needed to properly assess the opportunities. For example, useful studies may include identification of carbon-intensive materials to target in 'light weighting' projects.

The Clean Development Mechanism (CDM) and Joint Implementation (JI) under the Kyoto Protocol may offer opportunities to transfer best practice in waste prevention from Annex 1 countries (as identified under the Kyoto Protocol), however assistance is needed to find or apply suitable methodologies. This is also the case for projects focussed on resource recovery. Currently, no methodologies exist under CDM/JI that recognises the value of GHG savings associated with waste minimisation. There are accepted methodologies appropriate for fuel-switching and fossil fuel avoidance, which could be applied to certain waste minimisation projects, if these projects are structured to fit the methodologies.

Development for Clean Development Mechanism" Project was launched in 2002 and aims to improve understanding of CDM and develop the institutional and human capacity needed to develop and implement CDM projects. The effectiveness of this initiative and the possibility of further extending it need to be explored.

The role of the informal sector in resource recovery and associated climate change mitigation is largely overlooked due to a lack of information. Reclaimers require support to form co-operatives, access better equipment, negotiate direct access to waste sources, and generally improve their health, safety, and livelihood.

In summary, the following gaps are apparent across all the participating cities in South Africa (Refer to paragraph 8 for city specific gap analysis):

- Focus on the deployment of simple, proven waste practices and technologies.
- Development of marginal abatement cost curves to help inform funding priorities.
- Production of comprehensive waste reports and strategies within most of the cities (IWMP) and ensure that climate change are highlighted.
- Inadequate or lack of waste minimisation policy.
- Development of best practice in policy and programmes relevant to waste prevention and sustainable production and consumption.
- Investigate development of new CDM and JI methodologies for waste prevention practices, and to account for GHG savings gained through resource recovery (i.e. recycling), and provide guidance on application of existing methodologies to recycling and waste prevention projects.

- Support for the informal recycling sector, including recognition of the sector's role in sustainable waste management and resource recovery, protection of waste-pickers' livelihood, and improvement of health, safety, and general quality of life.
- Willingness of potential donors to fund projects in accordance with the priorities of the waste management hierarchy.

7.1. The IWM framework

The participating cities without approved and implemented Integrated Waste Management Systems (Table 2) should engage in a process to develop an IWMP to determine their shortcomings and way forward. The Integrated Waste Management (IWM) concept takes as a point of departure four basic principles:

- **Equity**: all citizens are entitled to an appropriate waste management system for environmental health reasons. Equity goes beyond a moral imperative because:
    - Pollution in one part of the city ultimately affects the rest of the city, including its air and water supply.
    - Polluted areas lead to poor living conditions. Abandoned waste is a symbol of a failed public service.
    - Unclean neighbourhoods can affect the city's economy and inhibit development.
- **Effectiveness** for waste management in general means that all waste is safely removed, as planned and all recoverable materials are recovered. The effectiveness of a service is the extent to which the objectives of the service have been met in practice. For example, a street sweeping service is effective if the streets are clean.
- **Efficiency**: the management of all waste is done by maximising the benefits, minimising the costs and optimising the use of resources, taking into account equity, effectiveness and sustainability. The benefits are balanced by all beneficiaries paying a reasonable cost to keep them that way, using the optimal combination of human resources, budget, equipment, machinery and management
- **Sustainability**: the waste management system is the best fit for the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective. It can maintain itself over time without exhausting the resources upon which it depends.

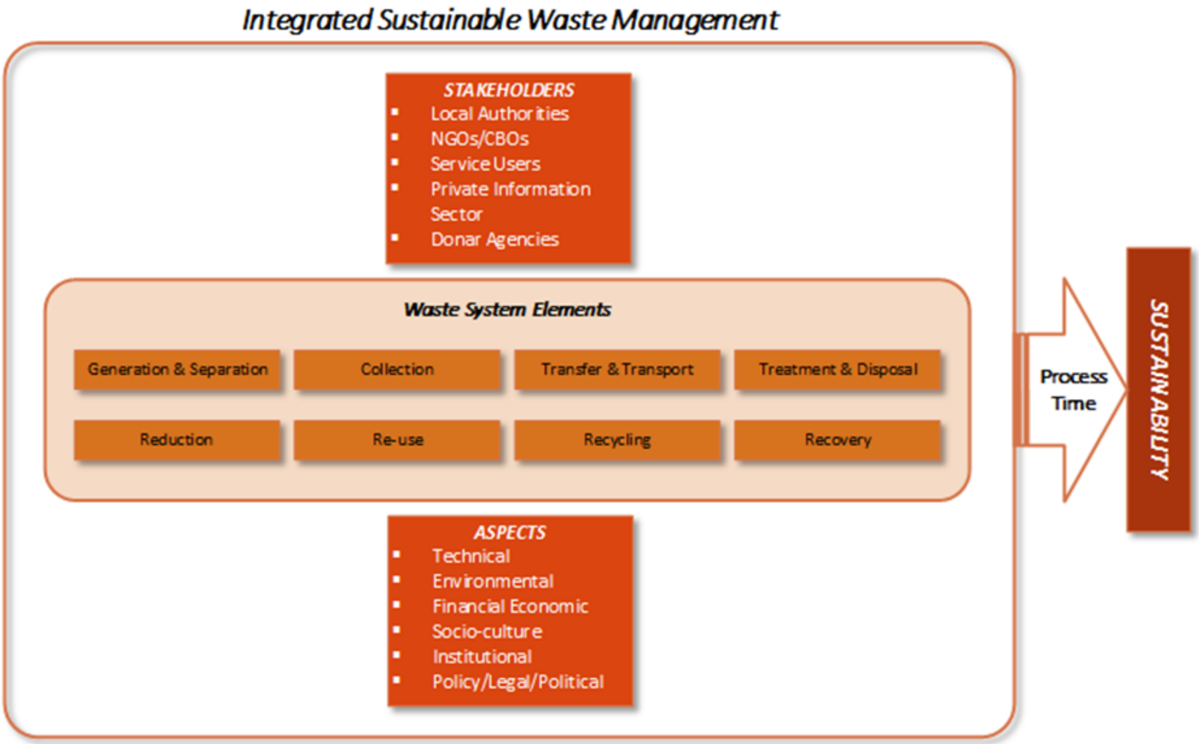

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Figure 9: Integrated Waste Management System[26]

IWMP has three major dimensions, Figure 9 refers:

- **Stakeholders** involved in waste management;
- The **elements** (practical and technical) of the waste system; and
- The **aspects** of the local context that should be taken into account when assessing and planning a waste management system.

7.2. Energy recovery

Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolyzation, anaerobic digestion, and landfill gas recovery. This process is called waste to energy (WtE). Energy recovery from waste is part of the non-hazardous waste management hierarchy. Using energy recovery to convert non-recyclable waste materials into electricity and heat, generates a renewable energy source and can reduce carbon emissions by offsetting the need for energy from fossil sources as well as reduce methane generation from landfills.

The energy content of waste products can be harnessed directly by using them as a direct combustion fuel, or indirectly by processing them into another type of fuel. Thermal treatment ranges from using waste as a fuel source for cooking or heating and the use of the gas fuel, to fuel for boilers to generate steam and electricity in a turbine. Pyrolysis and gasification are two related forms of thermal treatment where waste materials are heated to high temperatures with limited oxygen availability. The process usually occurs in a sealed vessel under high pressure. Pyrolysis of solid waste converts the material into solid, liquid and gas products. The liquid and gas can be burnt to produce energy or refined into other chemical products (chemical refinery). The solid residue (char) can be further refined into products such as activated carbon. Gasification and advanced Plasma arc gasification are used to convert organic materials directly into a synthetic gas (syngas) composed

[26] Integrated Sustainable Waste Management - the Concept, 2001, Arnold van de Klundert and Justine Anschütz

of carbon monoxide and hydrogen. The gas is then burnt to produce electricity and steam. An alternative to pyrolysis is high temperature and pressure supercritical water decomposition (hydrothermal monophasic oxidation).

7.3. Resource recovery

Resource recovery is the systematic diversion of waste, which was intended for disposal, for a specific next use. It is the processing of recyclables to extract or recover materials and resources, or convert to energy. These activities are performed at a resource recovery facility. Resource recovery is not only environmentally important, but it is also cost effective. It decreases the amount of waste for disposal, saves space in landfills, and conserves natural resources.

Resource recovery (as opposed to waste management) uses LCA[27] (life cycle analysis) attempts to offer alternatives to waste management. For general waste a number of studies have indicated that administration, source separation and collection followed by reuse and recycling of the non-organic fraction and energy and compost/fertilizer production of the organic material via anaerobic digestion is favourable. There are currently not many formalised municipal systems for source separation and kerbside collection of recyclables in South Africa; however this is possible because all the participating Cities have waste collection services in the urban areas.

Municipalities must promote awareness at all levels of society to instill a culture of change in mindset towards waste management in order to encourage more recycling. Local municipalities in general are less successful in diverting recycling material from landfill. Refer to Table 9.

Table 9: A contrast of good practice waste management between different categories of municipalities

Metropolitan Municipalities	**Local Municipalities**
Implementation of waste hierarchy into current plans and practices	Limitations that many of Local municipalities face in terms of capacity and financial resources to implement the waste hierarchy principles
Roll out of education and awareness programmes and campaigns	Inadequate planning which in turn results in local municipalities not meeting targets and expenditure of allocated financial budgets, resulting in poor service delivery
Encouraged implementation of separation at source	Inadequate by-laws and enforcement will result in poor compliance to implement separation at source initiatives
Outsourcing of waste service, i.e. CoCT made use of a recycling contractor throughout the city	No formalised recycling activities imposed by the municipalities.
Use of a rebate scheme put into place	Limitation on education and awareness as a large component of the population is rural
Imperative necessity to reduce waste streams from landfill	Waste generation patterns do not always allow for waste recycling to take place. Waste volumes can also play a role in recycling, as material cost and

[27] The life-cycle begins with design, then proceeds through manufacture, distribution, use and then follows through the waste hierarchy's stages of reuse, recovery, recycling and disposal.

Metropolitan Municipalities	Local Municipalities
	availability need to be further investigated for the establishment of a sustainable or profitable recycling plant.
Establishment of the very successful Kraaifontein MRF in CoCT	True cost of recycling is often not established and under costed which is a major problem. A cost model should be developed prior to the establishment of recycling initiatives, i.e. feasibility studies.

Recycling activities need financial and logistical support if it is to be successful and sustainable. Such support could include the following:

- Cash payment in return for materials delivered or collected e.g. at a buy back facility.
- Subsidies for collection and transport of materials for recycling.
- Establishing co-operatives.
- Enhancing market conditions for recycling by ensuring the supply.

7.4. Waste minimization

An important method of waste management is the prevention of the generation of waste material, also known as waste reduction. Methods of avoidance include reuse of second-hand products, repairing broken items instead of buying new ones, designing products to be refillable or reusable (such as cotton instead of plastic shopping bags), encouraging consumers to avoid using disposable products (such as disposable cutlery), removing any food/liquid remains from cans and packaging and designing products that use less material to achieve the same purpose (for example, light weighting of beverage cans).

7.5. Hypothetical scenario: Regional Landfill Site

Establishment of a regional landfill site is critical and urgent, as this will be required regardless of waste diversion and waste minimisation efforts; it is only the scale (size/ capacity) of the regional site that would be affected by the actual rollout of the waste minimisation strategy. The development of a regional landfill in the Gauteng region would provide relief to CoT, CoJ, EMM and Mogale City Municipality (Krugersdorp).

The graph below (Figure 10) depicts a hypothetical scenario showing status quo for an example starting at 2011 with recycling in place together with trends indicating airspace consumption with increased recycling i.e. 10%[28] of which is a national average and 25%[29] which is NWMS target. As recycling initiatives increase, so will airspace.

[28] An estimated 5.8 million tonnes of general waste was recycled (~10%) with the remaining 53 million tonnes of general waste being landfilled (National Waste Information Baseline Report, Draft 6, 5 September 2012)

[29] Goal 1: 25% of recyclables diverted from landfill for re-use, recycling or recovery by 2016, NWMS 2011

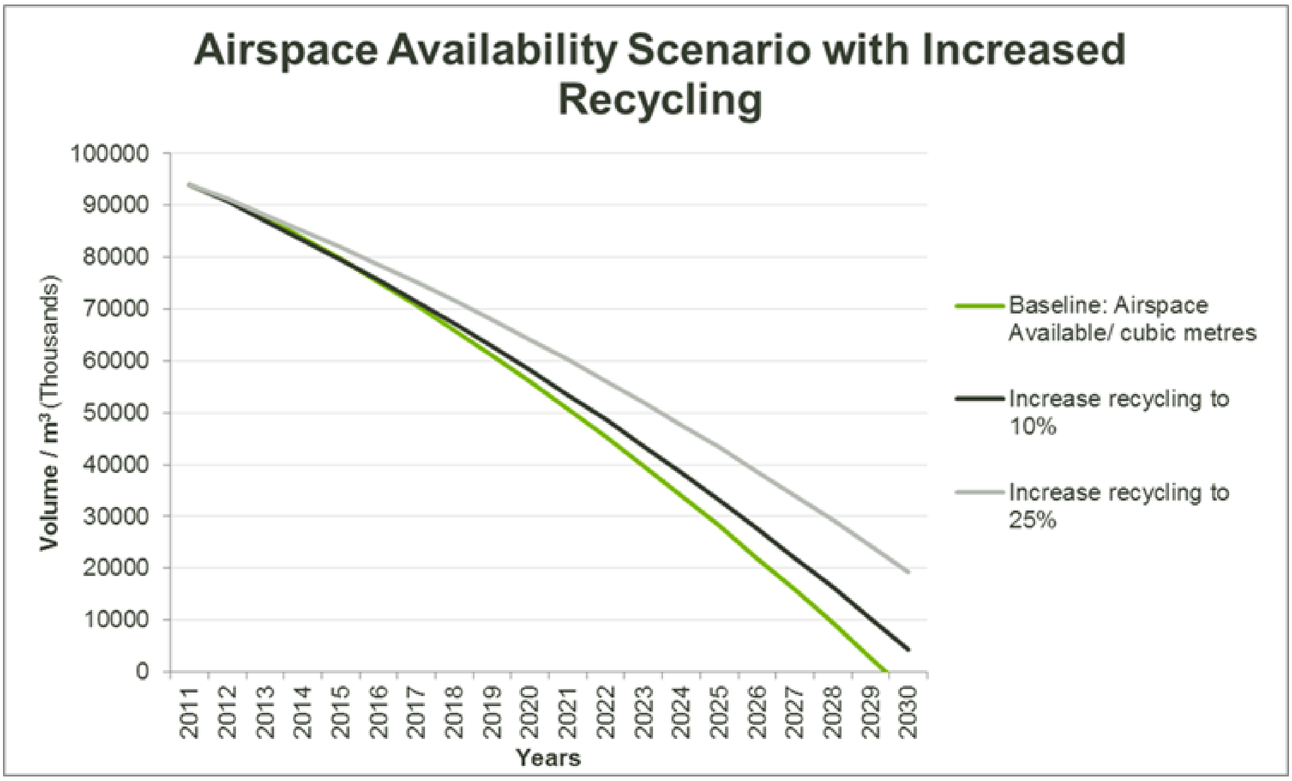

Figure 10: Hypothetical scenario of effects of increased recycling on airspace

7.6. Guiding principles

- **'Build on existing initiatives and strengths'** indicates that existing initiatives and actions are under way, and the objective is to build on and strengthen these while identifying gaps and areas to add value. Building on existing strengths helps to ensure buy-in and build trust, while enabling scarce resources to be used efficiently and effectively. This principle applies equally to the existing informal recycling sector.
- **'Partnerships and shared responsibilities'** recognises that a large number of institutions are involved in the area of waste and climate change (local and national), and that responsibility must be shared to ensure swift delivery of effective GHG prevention and mitigation measures in the waste sector.
- **'Best practice – best available technologies'** is a key principle where assistance is extended to cities where uncontrolled landfilling is the predominant practice. Although controlled landfilling may be a better practice, there may be a 'best available technology' or system that avoids disposal of untreated waste and recovers materials and/or energy. The 'best practice' in terms of the waste hierarchy is decoupling of waste generation from Gross domestic product (GDP) – this must be encouraged through sharing experiences in waste prevention and material recovery between cities.
- **'Recognise diversity – address disparity'** means that the diversity of approaches to integrated waste management and climate protection should be embraced and built upon, and knowledge and technology will be transferred to address the disparity in waste management capabilities.

8. Critical Success Factors and Recommendations

8.1. CoJ

Regardless of waste diversion and waste minimisation efforts, establishment of a new landfill site will be required. The scale (size/ capacity) of the new site should be informed by the rollout of waste minimisation actions.

It is recommended that strategies to minimize waste to landfill should be increased. Although CoJ currently has successful small-scale waste to energy projects as well as separation at source, implementation of waste treatment alternatives should be further investigated and adopted if proven feasible.

It is also suggested that the following be implemented:

- Explore alternative waste treatment technologies
- Introduce MRF's in various regions
- Increased community collection
- Operational improvements
- Implementation of the Waste Minimisation Strategy

8.2. CoCT

CoCT is considering PPP models to manage waste more effectively by creating synergies with Waste Water Treatment Plant (WWTP) for energy recovery, composting and MRF's leading to energy recovery which will in turn save landfill airspace. It is recommended that strategies on a minimisation drive should be increased as well as implementation of waste treatment alternatives.

Establishment of a new landfill site is critical and urgent, as this will be required regardless of waste diversion and waste minimisation efforts (see Figure 2). The scale (size/ capacity) of the new site should be informed by waste minimisation actions. It is also suggested that the following be implemented:

- Roll out of the Waste Minimisation Plan
- Involvement between technical advisory and government to build on a PPP model for inclusiveness and success
- Consider synergies with Waste Water Treatment Works and Landfills for co-generation of gas (Waste to energy)
- Development of more MRF's

8.3. Mangaung

Strategies toward waste minimisation drives should be effectively assessed to encourage reduced waste to landfill and direct community behavioral patterns towards waste disposal. The availability of the current footprints of the three landfill sites presents an ideal opportunity to develop an integrated waste management facility, i.e. WtE facility, MRF, Composting plant and a crushing and screening plant. This should be investigated and implemented if feasible.

It is also suggested that the following being implemented:

- Consider operational intervention, i.e. "Back to basics" on landfills
- More planning directives for It is recommended waste collection and separation
- Weak resources and skills at municipal level to carry out or support policies
- Develop a socio-model to engage the reclaimers to be "on-boarded" in the recycling programme at the landfill sites
- Greater education and awareness initiatives at community level in order too

- Excessive number of reclaimers, safety is a key concern
- Mixing of different waste streams e.g. builders rubble mixed with organics.
- Initiative to establish cooperatives for reclaimers.

8.4. eThekwini

eThekwini has successful programmes with regards to waste minimisation and it is advised that strategies are phased in the approach towards waste minimisation planning. Although this city currently has successful waste to energy projects, implementation of waste treatment alternatives should be further investigated and adopted if proven feasible.

As Bisasar Road Landfill is due for closure, eThekwini is considering a regional (mega) landfill site to manage waste from the whole of municipal area. The municipality is investigating developing localized landfills, with MRFs, such as Buffelsdraai landfill site to the North of the municipality.

8.5. Buffalo City

BCMM is faced with the challenge of adequately planning for short, medium and long term which has resulted in the current situation of minimal airspace, no new cell development, poor operational standards and lack of resources.

It is suggested that the following being implemented:

- Strategic planning intervention: Assess full waste generation to disposal cycle
- Waste Minimisation plan- engagements with stakeholders for buy in.
- Engagement with reclaimers to be inclusive in the separation and recovery initiatives on the landfill
- Explore waste treatment alternatives to be considered at the landfill as part of the integrated model.

8.6. Msunduzi

The New England Road landfill site is challenged with numerous reclaimers on the working face which poses health and safety risks. This further impact on the operations and planning processes for the officials.

It is suggested that the following being implemented:

- Look at a waste strategy inclusive of all the towns to implement a wider waste management solution.
- Develop a formal system for the number of reclaimers to deal with waste recycling and recovery
- Include greater planning around logistics, and allow for waste services for informal areas
-

8.7. CoT

Regardless of waste diversion and waste minimisation efforts, establishment of new cells on the existing landfill sites to bring about capacity for residual waste. The aged infrastructure creates challenges in terms of securing and operating the landfill sites in a compliant manner. The implementation of waste treatment alternatives is currently being investigated by CoT and should be implemented if proven feasible.

It is also suggested that the following being implemented:

- Establishment of a regional landfill site should be investigated and considered.
- Develop a comprehensive waste management strategy
- Technical support to direct the current landfilling operations and identify gaps that could be used in the assessment of alternative waste treatment Look at phased planning approach.

8.8. EMM

The current challenge in EMM is the lack of waste minimization approaches and the development of integrated waste management facility.

It is recommended that strategies toward a phased approach of waste minimisation planning should be increased. EMM currently has landfill gas projects at some of their landfill sites. Implementation of waste treatment alternatives should be further investigated and implemented if feasible.

It is also suggested that the following being implemented:

- Investigation of alternative waste disposal facilities to deal with rural waste
- Explore alternative waste treatment technologies
- Consider central area for disposal as landfill sites are not in close proximity to generation points
- Provision of adequate resources i.e. fleet Consider community based waste collection, i.e. job creation

8.9. Overarching recommendations

Waste products are not something that should be discarded or disposed of with no regard for future use. It can be a valuable resource if addressed correctly, through policy and practice. With rational and consistent waste management practices there is an opportunity to reap a range of benefits. Those benefits include:

- **Economic** - Improving economic efficiency through resource re-use, treatment and as a last resort, disposal which can lead to efficient practices in the production and consumption of products and materials resulting in valuable materials being recovered for reuse and the potential for new jobs and new business opportunities.

- **Social** – Through the development of education and awareness programmes implemented on grassroots level.

- **Environmental** - Reducing or eliminating adverse impacts on the environment through reducing, reusing and recycling, and maximising resource extraction can improve air and water quality and assist in the reduction of greenhouse emissions.

In addition, methane emissions from landfill represent the largest source of GHG emissions in the waste sector. Landfill remains the predominant waste disposal method in South Africa, and as landfill management improves methane emissions are anticipated to increase. LFG capture can considerably reduce methane emissions and, where the captured gas is used to generate energy, can lead to GHG reduction.

The strategic objectives sit within three over-arching goals:

- **Goal 1**: to minimise the impact of human activities on the climate

- **Goal 2**: to promote waste prevention and resource recovery, thereby reducing the climate impact of raw material extraction and manufacturing processes

- **Goal 3**: to support and promote sustainable waste management practices

It is recommended that:

- By-laws should be amended to include reasonable waste recovery initiatives for the implementation thereof to be enforced. This should be a phased in approach e.g. Year 1: Paper separation, Year 2: glass separation etc.

- The cities should change their Waste Management Policies and minimize climate change to include mandatory recycling and composting legislation. Recycling initiatives i.e. community composting programs and curbside recycling programs should therefore be further investigated.
- Increase education and awareness by developing programmes with realistic timelines to introduce sustainable solutions for implementation. The Executive management of the City should support this initiative.
- Each municipality should have an inclusive programme , providing 'user-friendly' recycling and composting services to all communities including small and rural communities, with the goal of reducing waste disposed to landfill in line with national targets.
- Provision of sufficient funding the collection and sorting of materials, develop infrastructure, and provide incentives to develop markets.
- Extensive education and communications programme to be developed to encourage comprehensive adoption.
- A vision statement must be developed in consultation with key stakeholders to ensure ownership of a strategy.
- Municipalities need to develop Integrated Waste Management Plans (IWMPs) and ensure alignment with the Integrated Development Planning (IDP) and budgeting process to secure funding for sustainable waste management practices.

Table 10: Actions are proposed – Based on the analysis of gaps identified, a number of actions are proposed. The below list is only indicative, and certainly not exclusive and should be implemented within the limitations of available financial resources. Actions should be implemented in priority according to the waste management hierarchy (i.e. actions pertaining to waste prevention and reduction would be implemented first).

Table 10: Actions

Identified gaps	Proposed actions
Development of best practice in waste prevention policy and programmes	Develop integrated resource policies, spanning the life-cycle of resources used in various goods and products.
CDM and JI methodologies for waste prevention practices, and to account for GHG savings gained through resource recovery (i.e. recycling).	Support research into viable methodologies for waste minimisation projects (i.e. validating GHG savings from materials recovered for recycling). Identify projects eligible for CDM and JI
Promotion of best-practice resource recovery systems and processing.	Investigate climate impacts of recycling processes and resource recovery
Support for informal recycling sector.	Promote legalisation of the informal waste sector Provide reclaimers with resources to form cooperatives, access funds for improved equipment, and agree on contracts for access to waste sources. Prepare strategies to ensure protection of livelihood and improvement of quality of life of the informal recycling sector.
Develop strategies for financing of waste	Develop strategies for the initiation and continuation of financing for waste management. Priority should

Identified gaps	Proposed actions
management activities	be given to development of local, sustainable funding mechanisms (i.e. waste disposal fees, public-private partnerships, out-sourcing to private sector). Ensure that funding emphasis is equally placed on waste collection systems and logistics, not only capital and infrastructure.

9. References

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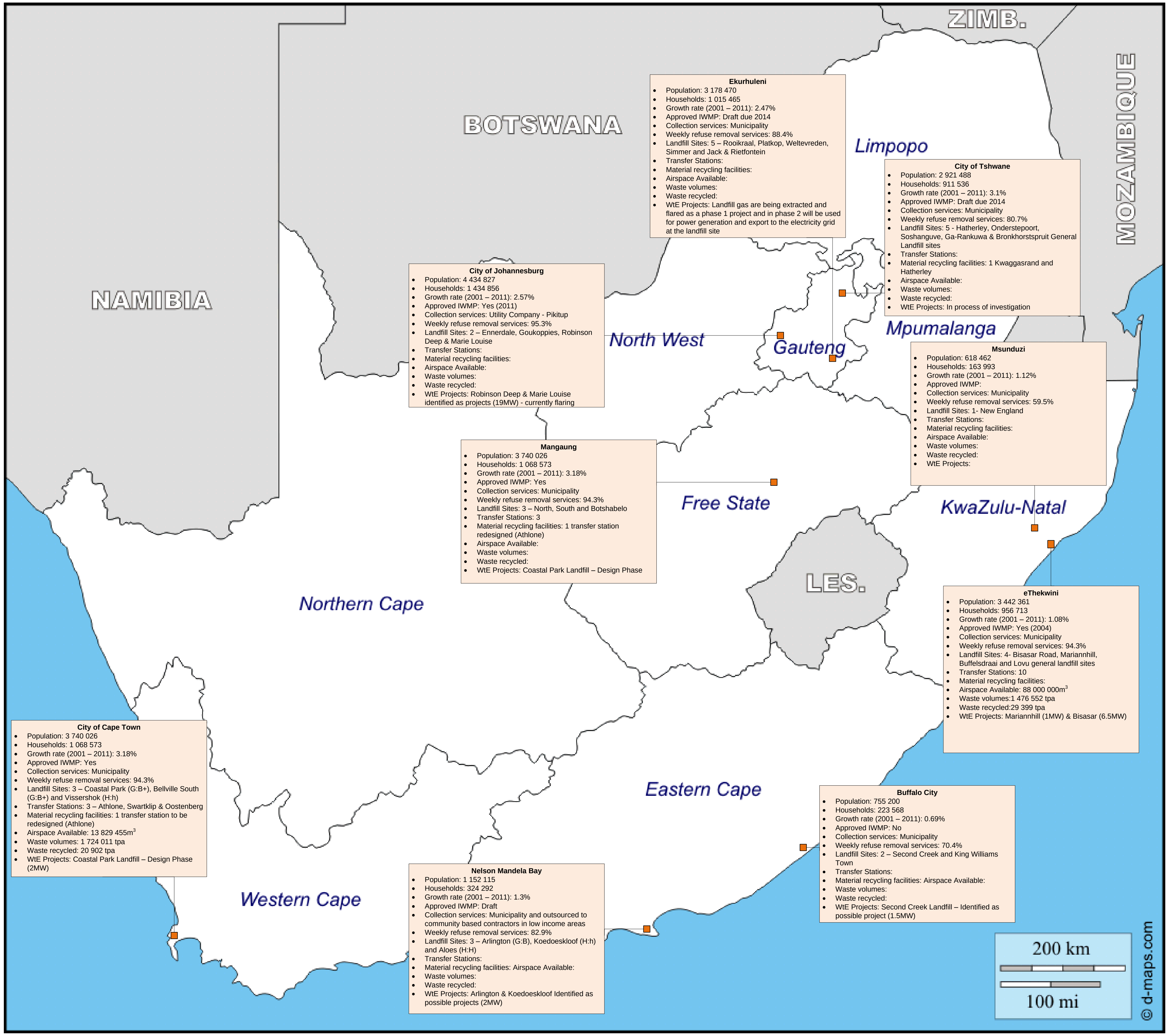
Annexure A

Demographics


ZIMB.
BOTSWANA
NAMIBIA
MOZAMBIQUE
LES.
Limpopo
North West
Gauteng
Mpumalanga
Free State
KwaZulu-Natal
Northern Cape
Eastern Cape
Western Cape
Ekurhuleni
Population: 3 178 470
Households: 1 015 465
Growth rate (2001 – 2011): 2.47%
Approved IWMP: Draft due 2014
Collection services: Municipality
Weekly refuse removal services: 88.4%
Landfill Sites: 5 – Rooikraal, Platkop, Weltevreden, Simmer and Jack & Rietfontein
Transfer Stations:
Material recycling facilities:
Airspace Available:
Waste volumes:
Waste recycled:
WtE Projects: Landfill gas are being extracted and flared as a phase 1 project and in phase 2 will be used for power generation and export to the electricity grid at the landfill site
City of Tshwane
Population: 2 921 488
Households: 911 536
Growth rate (2001 – 2011): 3.1%
Approved IWMP: Draft due 2014
Collection services: Municipality
Weekly refuse removal services: 80.7%
Landfill Sites: 5 - Hatherley, Onderstepoort, Soshanguve, Ga-Rankuwa & Bronkhorstspruit General Landfill sites
Transfer Stations:
Material recycling facilities: 1 Kwaggasrand and Hatherley
Airspace Available:
Waste volumes:
Waste recycled:
WtE Projects: In process of investigation
City of Johannesburg
Population: 4 434 827
Households: 1 434 856
Growth rate (2001 – 2011): 2.57%
Approved IWMP: Yes (2011)
Collection services: Utility Company - Pikitup
Weekly refuse removal services: 95.3%
Landfill Sites: 2 – Ennerdale, Goukoppies, Robinson Deep & Marie Louise
Transfer Stations:
Material recycling facilities:
Airspace Available:
Waste volumes:
Waste recycled:
WtE Projects: Robinson Deep & Marie Louise identified as projects (19MW) - currently flaring
Msunduzi
Population: 618 462
Households: 163 993
Growth rate (2001 – 2011): 1.12%
Approved IWMP:
Collection services: Municipality
Weekly refuse removal services: 59.5%
Landfill Sites: 1- New England
Transfer Stations:
Material recycling facilities:
Airspace Available:
Waste volumes:
Waste recycled:
WtE Projects:
Mangaung
Population: 3 740 026
Households: 1 068 573
Growth rate (2001 – 2011): 3.18%
Approved IWMP: Yes
Collection services: Municipality
Weekly refuse removal services: 94.3%
Landfill Sites: 3 – North, South and Botshabelo
Transfer Stations: 3
Material recycling facilities: 1 transfer station redesigned (Athlone)
Airspace Available:
Waste volumes:
Waste recycled:
WtE Projects: Coastal Park Landfill – Design Phase
eThekwini
Population: 3 442 361
Households: 956 713
Growth rate (2001 – 2011): 1.08%
Approved IWMP: Yes (2004)
Collection services: Municipality
Weekly refuse removal services: 94.3%
Landfill Sites: 4- Bisasar Road, Mariannhill, Buffelsdraai and Lovu general landfill sites
Transfer Stations: 10
Material recycling facilities:
Airspace Available: 88 000 000m^3
Waste volumes:1 476 552 tpa
Waste recycled:29 399 tpa
WtE Projects: Mariannhill (1MW) & Bisasar (6.5MW)
City of Cape Town
Population: 3 740 026
Households: 1 068 573
Growth rate (2001 – 2011): 3.18%
Approved IWMP: Yes
Collection services: Municipality
Weekly refuse removal services: 94.3%
Landfill Sites: 3 – Coastal Park (G:B+), Bellville South (G:B+) and Vissershok (H:h)
Transfer Stations: 3 – Athlone, Swartklip & Oostenberg
Material recycling facilities: 1 transfer station to be redesigned (Athlone)
Airspace Available: 13 829 455m^3
Waste volumes: 1 724 011 tpa
Waste recycled: 20 902 tpa
WtE Projects: Coastal Park Landfill – Design Phase (2MW)
Buffalo City
Population: 755 200
Households: 223 568
Growth rate (2001 – 2011): 0.69%
Approved IWMP: No
Collection services: Municipality
Weekly refuse removal services: 70.4%
Landfill Sites: 2 – Second Creek and King Williams Town
Transfer Stations:
Material recycling facilities: Airspace Available:
Waste volumes:
Waste recycled:
WtE Projects: Second Creek Landfill – Identified as possible project (1.5MW)
Nelson Mandela Bay
Population: 1 152 115
Households: 324 292
Growth rate (2001 – 2011): 1.3%
Approved IWMP: Draft
Collection services: Municipality and outsourced to community based contractors in low income areas
Weekly refuse removal services: 82.9%
Landfill Sites: 3 – Arlington (G:B), Koedoeskloof (H:h) and Aloes (H:H)
Transfer Stations:
Material recycling facilities: Airspace Available:
Waste volumes:
Waste recycled:
WtE Projects: Arlington & Koedoeskloof Identified as possible projects (2MW)
200 km
100 mi
© d-maps.com

Annexure B

Waste Management Indicators

Indicator	Description
Statistics	
Population	This is the actual statistics available
Households	
Municipal Area	
Waste Management Services	
Population	The indicator shows the number and percentage of households with access to weekly curb-side waste collection services. The indicator will measure the number of households within local authorities that have waste collected.
Households	
Municipal Area	
Service Providers	
Number of Sub-contractors	Providing services on behalf of City or privately
Number of Co-operatives	Providing services on behalf of City or privately
IWMP	
Status	Developed, approved or implemented?
Legislation Framework	
By-laws	Developed, approved or implemented?
Waste Policy	Developed, approved or implemented?
Budget	
Capital	This Indicator addresses the total annual budget spent on waste management.
Operating	
Income	
Capital Funding	Municipality/MIG/Other
Human Resources	

Indicator	Description
Waste management Officer	This indicator will give an indication of insufficiencies in waste management: • Is a designated Waste Management Officer appointed? • Amount of personnel appointed by the Municipality • Amount of personnel outsourced by the Municipality • Amount of posts vacant
Permanent	
Contract	
EPWP	
Assets	
Municipal Fleet	This will indicate if the municipality have the resources to render a waste management service.
Outsourced Fleet	
Access to Basic service	
Number of households **with** access to basic services	Basic services as described in relevant legislation (Households as per IDP/STATSA)
Number of households receiving WM services by the **Municipality**	Services rendered by the municipality
Number of households serviced by a **Service Provider**	
Number of household **without** access to WM services	
Number of Business/Industry serviced by the **Municipality**	
Number of Business/Industry serviced by a **Service Provider**	
Disposal Facilities	
Number of licensed **landfill sites owned by the Municipality**	This Indicator addresses the total annual amount of general waste disposed of at landfill sites. Indicator can be used to monitor and assess: • The movement of waste within the municipality from the point of generation to final destination; • Waste generation;
Number of unlicensed **landfill sites**	
Annual tons of waste to Municipal **landfill sites**	
Airspace available	

Indicator	Description
Number of licensed **landfill sites owned Privately**	• Waste minimisation initiatives; and • Recycling initiatives; • Airspace availability.
Annual tons of waste to **Privately owned** landfill sites	
Number of **transfer stations**	
Annual tons of waste received a **transfer station**	
Waste Generation	
Has waste characterization been done?	To monitor and assess: • Increase in waste generation; • General and hazardous waste production; • Waste recovery;
Amount of **general** Waste Generated	
Amount of **hazardous** Waste Generated	
Amount of **garden** Waste Generated	
Amount of **builders rubble** Generated	
Processing and Resource Recovery	
Number of **buy back centres**	Indicate if it is property of municipality or privately owned
Number of **Material Recycling Centres**	
Number of **drop off zones**	
Total annual tons of waste recycled:	
Plastic recycled	The aim of indicator is to monitor and assess: • Trends towards sustainability, by increasing recycling; • The effectiveness of policy and programme implementation, in recycling initiatives
Glass recycled	
Paper recycled	
Cans recycled	
Metal recycled	

Indicator	Description
Cardboard recycled	
Waste-to-energy	
Number of initiatives	
Carbon trading	Credits to reduce emissions of carbon dioxide
Electricity	MW Electricity Generated

Annexure C

Results: State of Waste Management in Cities

STATE OF WASTE MANAGEMENT eTHEKWINI

YEAR	HOUSEHOLDS	WASTE PER HOUSEHOLD	WASTE VOLUMES TONNAGES	WASTE VOLUMES CUBIC METRES	AIRSPACE AVAILABLE CUBIC METRES	WASTE RECYCLED TONNAGES	PERCENTAGE OF WASTE RECYCLED	PLASTIC	GLASS	PAPER	CANS	METAL	CARDBOARD	OPERATING BUDGET	INCOME	SURPLUS/ DEFICIT	CAPITAL
2011	903562	1.39	1253903	3550658	94000000	20907	1.67	2502	805	5090	158	980	11372	793945414		-793945414	86908000
2012	903562	1.64	1485508	4206490	91000000	22287	1.50	2710	933	5340	174	1234	11896	815146434		-815146434	211860000
2013	945910	1.56	1476552	4181130	88000000	29399	1.99	2509	1266	4920	245	8584	11875	902360851		-902360851	168806000
2014	945910	1.53	1450000	4105943	85000000	32690	2.25	2581	1462	4947	279	11203	12217	988791770		-988791770	13876800
2015	967084	1.61	1561325	4421179	82000000	36936	2.37	2584	1693	4862	323	15005	12469			0	
2016	984023	1.65	1619258	4585228	79000000	41182	2.54	2588	1923	4777	366	18807	12720			0	
2017	1000962	1.68	1677192	4749277	76000000	45428	2.71	2591	2154	4692	410	22609	12972			0	
2018	1017902	1.70	1735125	4913327	73000000	49674	2.86	2595	2384	4607	453	26411	13223			0	
2019	1034841	1.73	1793059	5077376	70000000	53920	3.01	2598	2615	4522	497	30213	13475			0	
2020	1051780	1.76	1850992	5241426	67000000	58166	3.14	2602	2845	4437	540	34015	13726			0	
2021	1068719	1.79	1908926	5405475	64000000	62412	3.27	2605	3076	4352	584	37817	13978			0	
2022	1085658	1.81	1966859	5569524	61000000	66658	3.39	2609	3306	4267	627	41619	14229			0	
2023	1102598	1.84	2024793	5733574	58000000	70904	3.50	2612	3537	4182	671	45421	14481			0	
2024	1119537	1.86	2082726	5897623	55000000	75150	3.61	2616	3767	4097	714	49223	14732			0	
2025	1136476	1.88	2140660	6061673	52000000	79396	3.71	2619	3998	4012	758	53025	14984			0	
2026	1153415	1.91	2198593	6225722	49000000	83642	3.80	2623	4228	3927	801	56827	15235			0	
2027	1170354	1.93	2256527	6389771	46000000	87888	3.89	2626	4459	3842	845	60629	15487			0	
2028	1187294	1.95	2314460	6553821	43000000	92134	3.98	2630	4689	3757	888	64431	15738			0	
2029	1204233	1.97	2372394	6717870	40000000	96380	4.06	2633	4920	3672	932	68233	15990			0	
2030	1221172	1.99	2430327	6881920	37000000	100626	4.14	2637	5150	3587	975	72035	16241			0	

STATE OF WASTE MANAGEMENT CITY OF CAPE TOWN																	
YEAR	HOUSEHOLDS	WASTE PER HOUSEHOLD	WASTE VOLUMES TONNAGES	WASTE VOLUMES CUBIC METRES	AIRSPACE AVAILABLE CUBIC METRES	WASTE RECYCLED TONNAGES	PERCENTAGE OF WASTE RECYCLED	PLASTIC	GLASS	PAPER	CANS	METAL	CARDBOARD	OPERATING BUDGET	INCOME	SURPLUS/ DEFICIT	CAPITAL
2011	902278	1.87	1685927	4774014	16641882	13620	0.81	3360	3303	3637		1351	1969	1837700801	1059884885	-777815916	208342365
2012	902278	1.96	1765402	4999062	14792733	13532	0.77	2771	3079	3604		1629	2449	1917289772	1124817958	-792471814	230652929
2013	1068575	1.61	1724011	4881856	13829455	20902	1.21	4289	5551	4423		2306	4333	2090813423	1255032462	-835780961	214173300
2014	1068575	1.65	1763197	4992819	12275596	23300	1.32	4402	6226	4674		2717	5281			0	13876800
2015	1151724	1.55	1782239	5046740	10869383	26941	1.51	4867	7350	5067		3195	6463			0	
2016	1218242	1.48	1801281	5100661	9463169	30582	1.70	5331	8474	5460		3672	7645			0	
2017	1284761	1.42	1820323	5154582	8056956	34223	1.88	5796	9598	5853		4150	8827			0	
2018	1351280	1.36	1839365	5208503	6650742	37864	2.06	6260	10722	6246		4627	10009			0	
2019	1417799	1.31	1858407	5262424	5244529	41505	2.23	6725	11846	6639		5105	11191			0	
2020	1484318	1.26	1877449	5316344	3838315	45146	2.40	7189	12970	7032		5582	12373			0	
2021	1550836	1.22	1896491	5370265	2432102	48787	2.57	7654	14094	7425		6060	13555			0	
2022	1617355	1.18	1915533	5424186	1025888	52428	2.74	8118	15218	7818		6537	14737			0	
2023	1683874	1.15	1934575	5478107	-380325	56069	2.90	8583	16342	8211		7015	15919			0	
2024	1750393	1.12	1953617	5532028	-1786539	59710	3.06	9047	17466	8604		7492	17101			0	
2025	1816912	1.09	1972659	5585949	-3192752	63351	3.21	9512	18590	8997		7970	18283			0	
2026	1883430	1.06	1991701	5639870	-4598966	66992	3.36	9976	19714	9390		8447	19465			0	
2027	1949949	1.03	2010743	5693791	-6005179	70633	3.51	10441	20838	9783		8925	20647			0	
2028	2016468	1.01	2029785	5747712	-7411393	74274	3.66	10905	21962	10176		9402	21829			0	
2029	2082987	0.98	2048827	5801633	-8817606	77915	3.80	11370	23086	10569		9880	23011			0	
2030	2149506	0.96	2067869	5855554	-10223820	81556	3.94	11834	24210	10962		10357	24193			0	

STATE OF WASTE MANAGEMENT CITY OF JOHANNESBURG																	
YEAR	HOUSEHOLDS	WASTE PER CAPITA	WASTE VOLUMES TONNAGES	WASTE VOLUMES CUBIC METRES	AIRSPACE AVAILABLE CUBIC METRES	WASTE RECYCLED TONNAGES	PERCENTAGE OF WASTE RECYCLED	PLASTIC	GLASS	PAPER	CANS	METAL	TOTAL WASTE RECYCLED	OPERATING BUDGET	REVENUE	SURPLUS/ DEFICIT	CAPITAL
2011	1006910	1.41	1416286	4010475.3	15714707	31860	2.25						31860	1265749000	277665000	-988084000	54200000
2012	1434856	1.02	1468238	4157587	14624536	32679	2.23						32679	1318782000	301294000	-1017488000	62000000
2013	1434856	1.06	1520190	4304698.7	13465018	33519	2.20						33519	1396494000	335406000	-1061088000	69800000
2014	1720153	0.91	1572142	4451810.4	12409521	34345	2.18						34345			0	
2015	1934126	0.84	1624094	4598922.1	11284677	35175	2.17						35175			0	
2016	2148099	0.80	1728000	4893151.1	10206064	36004	2.08						36004			0	
2017	2362072	0.77	1829200	5179717.6	9096630	36834	2.01						36834			0	
2018	2576045	0.75	1930400	5466284.1	8007744	37663	1.95						37663			0	
2019	2790018	0.73	2031600	5752850.6	6905159	38493	1.89						38493			0	
2020	3003991	0.71	2132800	6039417	5811706	39322	1.84						39322			0	
2021	3217964	0.69	2234000	6325983.5	4712166	40152	1.80						40152			0	
2022	3431937	0.67	2306667	6531753.6	3616684	40981	1.78						40981			0	
2023	3645910	0.65	2379334	6737523.6	2518496	41811	1.76						41811			0	
2024	3859883	0.64	2452001	6943293.6	1422112	42640	1.74						42640			0	
2025	4073856	0.62	2524668	7149063.6	324526	43470	1.72						43470			0	
2026	4287829	0.61	2597335	7354833.7	-772259	44299	1.71						44299			0	
2027	4501802	0.59	2670002	7560603.7	-1869578	45129	1.69						45129			0	
2028	4715775	0.58	2742669	7766373.7	-2966541	45958	1.68						45958			0	
2029	4929748	0.57	2815336	7972143.8	-4063741	46788	1.66						46788			0	
2030	5143721	0.56	2888000	8177905.3	-5160783	47617	1.65						47617			0	

STATE OF WASTE MANAGEMENT CITY OF TSHWANE																	
YEAR	HOUSEHOLDS	WASTE PER CAPITA	WASTE VOLUMES TONNAGES	WASTE VOLUMES CUBIC METRES	AIRSPACE AVAILABLE CUBIC METRES	WASTE RECYCLED TONNAGES	PERCENTAGE OF WASTE RECYCLED	PLASTIC	GLASS	PAPER	CANS	METAL	TOTAL WASTE RECYCLED	OPERATING BUDGET	REVENUE	SURPLUS/ DEFICIT	CAPITAL
2011	606025	1.93	1168595	3309093	170000000	292148	25.00						292148			0	
2012	911536	1.32	1204821	3411673	160000000	301205	25.00						301205	972841000	689490000	-283351000	52500000
2013	911536	1.36	1241047	3514254	156000000	310262	25.00						310262	933235000	831856000	-101379000	17500000
2014	1115210	1.15	1277273	3616834	148000000	319319	25.00						319319			0	
2015	1267966	1.04	1313499	3719415	141000000	328376	25.00						328376			0	
2016	1420721	0.95	1349725	3821996	134000000	337433	25.00						337433			0	
2017	1573477	0.88	1385951	3924576	127000000	346490	25.00						346490			0	
2018	1726232	0.82	1422177	4027157	120000000	355547	25.00						355547			0	
2019	1878988	0.78	1458403	4129737	113000000	364604	25.00						364604			0	
2020	2031743	0.74	1494629	4232318	106000000	373661	25.00						373661			0	
2021	2184499	0.70	1530855	4334899	99000000	382718	25.00						382718			0	
2022	2337254	0.67	1567081	4437479	92000000	391775	25.00						391775			0	
2023	2490010	0.64	1603307	4540060	85000000	400832	25.00						400832			0	
2024	2642765	0.62	1639533	4642640	78000000	409889	25.00						409889			0	
2025	2795521	0.60	1675759	4745221	71000000	418946	25.00						418946			0	
2026	2948276	0.58	1711985	4847802	64000000	428003	25.00						428003			0	
2027	3101032	0.56	1748211	4950382	57000000	437060	25.00						437060			0	
2028	3253787	0.55	1784437	5052963	50000000	446117	25.00						446117			0	
2029	3406543	0.53	1820663	5155543	43000000	455174	25.00						455174			0	
2030	3559298	0.52	1856889	5258124	36000000	464231	25.00						464231			0	

STATE OF WASTE MANAGEMENT EKURHULENI																		
YEAR	HOUSEHOLDS	WASTE PER CAPITA	NUBER OF LANDFILL SITES	WASTE VOLUMES TONNAGES	WASTE VOLUMES CUBIC METRES	AIRSPACE AVAILABLE CUBIC METRES	WASTE RECYCLED TONNAGES	PERCENTAGE OF WASTE RECYCLED	PLASTIC	GLASS	PAPER	CANS	METAL	CARDBOARD	OPERATING BUDGET	REVENUE	SURPLUS/ DEFICIT	CAPITAL
2011	1015465	1.44	5	1466328	4152179	47489733	1007	0.07	155	177	136		24	515	983393000	1181954000	198561000	137284000
2012	1040546	1.44	5	1503464	4257336	46345012	2484	0.17	382	437	335		58	1272	1063060000	1337504000	274444000	125600000
2013	1065627	1.45	5	1540600	4362493	45200290	3961	0.26	609	697	534		92	2029	1156770000	1532096000	375326000	120032000
2014	1090708	1.45	5	1577736	4467651	44055569	5438	0.34	836	957	733		126	2786			0	
2015	1115789	1.45	5	1614872	4572808	42910847	6916	0.43	1063	1217	932		161	3543			0	
2016	1140870	1.45	5	1652008	4677966	41766126	8393	0.51	1290	1477	1131		195	4300			0	
2017	1165951	1.45	5	1689144	4783123	40621404	9870	0.58	1517	1737	1330		229	5057			0	
2018	1191032	1.45	5	1726280	4888281	39476683	11347	0.66	1744	1997	1529		263	5814			0	
2019	1216113	1.45	5	1763416	4993438	38331961	12824	0.73	1971	2257	1728		297	6571			0	
2020	1241194	1.45	5	1800552	5098595	37187240	14302	0.79	2198	2517	1927		332	7328			0	
2021	1266275	1.45	5	1837688	5203753	36042518	15779	0.86	2425	2777	2126		366	8085			0	
2022	1291356	1.45	5	1874824	5308910	34897797	17256	0.92	2652	3037	2325		400	8842			0	
2023	1316437	1.45	5	1911960	5414068	33753075	18733	0.98	2879	3297	2524		434	9599			0	
2024	1341518	1.45	5	1949096	5519225	32608354	20210	1.04	3106	3557	2723		468	10356			0	
2025	1366599	1.45	5	1986232	5624383	31463632	21688	1.09	3333	3817	2922		503	11113			0	
2026	1391680	1.45	5	2023368	5729540	30318911	23165	1.14	3560	4077	3121		537	11870			0	
2027	1416761	1.45	5	2060504	5834698	29174189	24642	1.20	3787	4337	3320		571	12627			0	
2028	1441842	1.45	5	2097640	5939855	28029468	26119	1.25	4014	4597	3519		605	13384			0	
2029	1466923	1.46	5	2134776	6045012	26884746	27596	1.29	4241	4857	3718		639	14141			0	
2030	1492004	1.46	5	2171912	6150170	25740025	29074	1.34	4468	5117	3917		674	14898			0	

STATE OF WASTE MANAGEMENT MANGAUNG

YEAR	HOUSEHOLDS	WASTE PER CAPITA	WASTE VOLUMES TONNAGES	WASTE VOLUMES CUBIC METRES	AIRSPACE AVAILABLE CUBIC METRES	WASTE RECYCLED TONNAGES	PERCENTAGE OF WASTE RECYCLED	PLASTIC	GLASS	PAPER	CANS	METAL	CARDBOARD	OPERATING BUDGET	REVENUE	SURPLUS/ DEFICIT	CAPITAL
2011	733302	0.79	579852	1641958	35340070	0	0.00							100849000	6491000	-94358000	7948000
2012	823316	0.71	588504	1666458	34820570	0	0.00							107633000	120485000	12852000	11530000
2013	823316	0.73	597155	1690955	34301070	0	0.00							124985000	190712000	65727000	13550000
2014	883325	0.69	605806	1715452	33781570	0	0.00									0	
2015	928332	0.66	614457	1739948	33262069	0	0.00									0	
2016	973339	0.64	623108	1764445	32742569	0	0.00									0	
2017	1018346	0.62	631759	1788942	32223069	0	0.00									0	
2018	1063353	0.60	640410	1813439	31703569	0	0.00									0	
2019	1108360	0.59	649061	1837936	31184069	0	0.00									0	
2020	1153367	0.57	657712	1862433	30664569	0	0.00									0	
2021	1198374	0.56	666363	1886930	30145068	0	0.00									0	
2022	1243381	0.54	675014	1911427	29625568	0	0.00									0	
2023	1288388	0.53	683665	1935924	29106068	0	0.00									0	
2024	1333395	0.52	692316	1960421	28586568	0	0.00									0	
2025	1378402	0.51	700967	1984918	28067068	0	0.00									0	
2026	1423409	0.50	709618	2009414	27547568	0	0.00									0	
2027	1468416	0.49	718269	2033911	27028067	0	0.00									0	
2028	1513423	0.48	726920	2058408	26508567	0	0.00									0	
2029	1558430	0.47	735571	2082905	25989067	0	0.00									0	
2030	1603437	0.46	744222	2107402	25469567	0	0.00									0	

Annexure D

Guidelines for Use of the Model

STATE OF WASTE MANAGEMENT CITY OF CAPE TOWN																	
YEAR	HOUSEHOLDS	WASTE PER CAPITA	WASTE VOLUMES TONNAGES	WASTE VOLUMES CUBIC METRES	AIRSPACE AVAILABLE CUBIC METRES	WASTE RECYCLED TONNAGES	PERCENTAGE OF WASTE RECYCLED	PLASTIC	GLASS	PAPER	CANS	METAL	CARDBOARD	OPERATING BUDGET	INCOME	SURPLUS/ DEFICIT	CAPITAL
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

COLUMN	INDICATOR	INSTRUCTION
1.	YEAR	Indicate current year
2.	HOUSEHOLDS	Enter number of households as per STATSSA, IDP
3.	WASTE PER CAPITA	Fixed as per formula
4.	WASTE VOLUMES TONNAGES	Indicate the volumes per ton of waste disposed of for this year
5.	WASTE VOLUMES CUBIC METRES	Fixed as per formula
6.	AIRSPACE AVAILABLE CUBIC METRES	Indicate surveyed airspace available
7.	WASTE RECYCLED TONNAGES	Fixed as per formula
8.	PERCENTAGE OF WASTE RECYCLED	Fixed as per formula
9.	PLASTIC	Enter Volume of plastic recycled per ton weighed
10.	GLASS	Enter Volume of glass recycled per ton weighed
11.	PAPER	Enter Volume of paper recycled per ton
12.	CANS	Enter Volume of cans recycled per ton
13.	METAL	Enter Volume of metal recycled per ton
14.	CARDBOARD	Enter Volume of cardboard recycled per ton
15.	OPERATING BUDGET	Indicate the operational funds budget for the current year
16.	INCOME	Indicate the operational funds budget for the current year
17.	SURPLUS/DEFICIT	Fixed as per formula
18.	CAPITAL	Enter total budget for capital projects