Western Cape Government
Environmental Affairs & Development Planning

Guideline for the management of Green Waste in the Western Cape

March 2018

Table of Contents

Table of Contents 2
Acronyms 5
Definitions 7
Executive Summary 10
1. Introduction 12
1.1. Strategic Alignment 15
2. Legislative requirements for the management of green waste 16
2.1. Specific Legislative Requirements for different treatment options 22
2.2. The waste management hierarchy 26
3. Provincial position on organics 27
4. Overview of key findings of the Green Waste Status Quo Report 28
5. Treatment options for the management of green waste 31
5.1. Composting 31
5.1.1. Legislation relating to composting in South Africa 33
5.1.2. The Basic Composting Steps 33
5.2. Waste to Energy 34
5.2.1. Biochar 35
5.2.2. Gasification 37
5.2.3. Pyrolysis (Direct Combustion: in a boiler/wood fired boilers) 38
5.2.4. Torrefaction (to increase energy density) 39
5.2.5. Air curtain burners 40
5.2.6. Anaerobic Digestion (Biogas) 41
5.2.7. Co-mingled options for the processing of green waste with other organics 46
5.3. Fires 46
Sectors generating green or wood waste 48
6. Agriculture 49
6.1. Overview of challenges in the sector 49
6.2. Green Waste generating sectors in agriculture 50
6.2.1. Horticulture 50
6.2.1.1. Flower industry 50
6.2.1.2. Nurseries 50

6.2.1.3. Beneficiation options for Horticulture 51
6.2.2. Orchards and Vineyards 53
6.2.2.1. Beneficiation options for waste generated from orchards and vineyards 53
6.2.2.1.1. Extracts 53
6.2.2.1.2. Wood 53
6.2.3. Cereal 54
6.2.3.1. Building materials for housing 55
6.2.3.2. Feed and bedding 55
6.2.3.3. Mushroom cultivation 56
6.2.3.4. Pulp 56
6.2.3.5. Cellulosic Ethanol 56
6.2.3.6. Biofuel 56
7. Forestry 57
7.1. Overview of challenges in the sector 57
7.2. Waste management options 60
7.2.1. Possible beneficiation of wood waste 60
7.2.1.1. Sludge 61
7.2.1.2. Energy generation 63
7.2.1.3. Beneficiation of wood waste from saw mills 65
8. Alien Clearing 65
8.1. Overview of challenges in the sector 65
8.2. Treatment options for waste generated from alien clearing 68
8.3. Potential value of cleared Invasive Alien Plants 69
8.3.1. Economic 69
8.3.2. Environmental 69
8.3.3. Social 70
8.4. Potential value added products from alien clearing waste 70
8.5. The role of Natural Resource Management Programme 74
8.5.1. Working for Water 75
8.5.2. Working for Wetland 76
8.5.3. Working on Fire 76
8.5.4. Working for Land 76
8.6. Value added chain 76

8.7. Case studies 78
8.7.1. Provincial 78
8.7.1.1. Waste to Energy: SENFORE Gasification Technologies 78
8.7.2. National 79
8.7.2.1. Biomass to energy: Sappi 79
8.7.2.2. Composting: Carbon reservoirs 79
8.7.2.3. Heat energy: Biomass pellets 80
8.7.2.4. School desks from alien biomass 80
9. Kelp/Seaweed 82
10. Municipalities 83
10.1. Setting up and the management of drop-off facilities 83
10.2. Procuring the services of a contractor for the handling, chipping and removal of green waste at facilities 84
10.3. Green Waste collection systems 85
10.4. CAPEX and OPEX requirements 88
10.5. Municipal benefits of diverting green waste from the domestic waste stream 90
10.6. Public awareness initiatives. 90
10.7. Setting up of PPP for the management of green waste 91
10.8. Funding your green waste management facility 92
11. Conclusion 93
References 95
Annexures A – Composting 99
Annexures B – Public-Private Partnership 112
Annexure C - Tender specifications based on the city of Cape Town's tender requirements 118

Acronyms

AD	Anaerobic Digestion
CARA	The Conservation of Agricultural Resource Act, No. 43 of 1983
CFR	Cape Floristic Region
CoCT	City of Cape Town
CSIR	Council for Scientific and Industrial Research
DEA&DP	Department of Environmental Affairs and Development Planning
DEA	Department of Environmental Affairs
DoA	Department of Agriculture
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
GDP	Gross Domestic Product
GNR	Government Notice Regulation
IAPs	Invasive Alien Plants
IP&WM	The White Paper on Integrated Pollution and Waste Management
IWMP	Integrated Waste Management Policy
IWMSA	Institute of Waste Management of South Africa
LED	Local Economic Development
MFMA	Municipal finance Management Act (Act No. 56 0f 2003)
MTSF	Medium-Term Strategic Framework
N&S	Norms and Standards

NDP	National Development Plan
NEM: AQA	National Environmental Management: Air Quality (Act No. 39 of 2004)
NEM: WA	National Environmental Management: Waste Act (Act No. 59 of 2008)
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NEM: BA	National Environmental Management Biodiversity (Act, No. 10 of 2004)
NGO	Non-governmental organisation
NOWCS	The National Organic Waste Composting Strategy
NRM	National resource management Programme
NWA	National Water Act (Act No. 36 of 1998)
PSP	Provincial Strategic Plan
RAG	Recycling Action Group
SanParks	South African National Parks
T	tonnes
t/a	tonnes per annum
VAI	value added industries
WC	Western Cape
WCG	Western Cape Government
WCMR	Waste Classification and Management Regulations
WDF	Waste Disposal Facility
WDF	Waste Disposal Facility
WFF	Working for Fire
WFL	Working for Land
WfW	Working for Water

WFW Working for Wetland

Definitions

Air pollution means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, and solid particles of any kind, gases, fumes, aerosols and odorous substances.

Aquifer means a geological formation which has structures or textures that hold water or permit appreciable water movement through them.

Biomass is the total mass of living matter within a given unit of environmental area.

Cape Floristic Region is the smallest of six recognised floral kingdoms in the world. It is also an area of extraordinary high diversity and endemism, and is home to over 9000 vascular plant species of which 69% are endemic.

Carbon Nitrogen ratio: The ratio of the weight of organic carbon (C) to that of total nitrogen (N) in an organic material.[1]

Compost means a stabilised, homogenous, fully decomposed substance of animal or plant origin to which no plant nutrients have been added and that is free of substances or elements that could be harmful to man, animal, plant, or the environment.

Composting Facility is a facility for the aerobic decomposition of biodegradable organic matter to produce compost.

Disposal means the burial, deposit, discharge, abandoning, dumping, placing or release of any waste into, or onto, any land.

Diversion rate is the percentage of waste material diverted from a Waste Disposal Facility. It can be measured in volume or weight.

Drop-off facility is a location where recyclable or compostable materials are dropped off by consumers without receiving payment for the materials.

[1] Compost Guideline. Environment Protection Authority, Adelaide, January 2013.

Green waste is a subsection of organic waste. The term refers to organic biodegradable materials such as grass cuttings, leaves, soil, branches, and other woody waste generated from gardens and parks, trimmings from forestry and agriculture, and from the clearing of alien vegetation.

Humification is the formation of humus during the decomposition of organic matter in soils.

Incineration means any method, technique, or process to convert waste to gases and residues by means of oxidations.

Invasive Alien Pants are plants that have been introduced in South Africa either intentionally (e.g., for ornamental use or agroforestry purposes) or accidentally (e.g., as ballast or in livestock feed).

Landfill airspace can be defined as the volume of space on a landfill site (Due to current amended legislation the term landfill is no longer used and has been replaced by Waste Disposal Facility) which is permitted for the disposal of municipal solid waste (MSW). This space is initially occupied by air which will eventually be displaced by the disposed waste — hence the term "landfill airspace."

Leachate is any liquid material that drains from land or stockpiled material and contains significantly elevated concentrations of undesirable material derived from the material that it has passed through.

Materials Recovery Facility (MRF) is a specialised plant that receive, separate, and prepare recyclable materials for the market e.g., end-user manufacturers and/or recycling companies. It is a waste management facility where waste received is separated into several waste streams such as cardboard, metal, paper, plastics, etc., by using either an automated system or, as in most cases, a manual system where workers hand pick the different recyclables and place them in dedicated containers for subsequent compaction and bailing.

Recovery means the controlled extraction or retrieval of any substance, material, or object from waste.

Recycle means a process where waste is reclaimed for further use, which process involves the separation of waste from a waste stream for further use and the processing of that separated material as a product or raw material.

Refuse Transfer Stations (RTS) are facilities for interim storage in preparation for recycling or landfilling respectively.

Re-use means to utilise the whole, a portion of or a specific part of any substance, material, or object from the waste stream for a similar or different purpose without changing the form or properties of such substance, material, or object.

Storage means the accumulation of waste in a manner that does not constitute treatment or disposal of that waste.

Value-added is used to characterize products that are converted from raw product through processes that give the resulting product an "incremental value" in the marketplace.

Waste Beneficiation described as the processing or treatment of waste to extract or produce valuable products.

Waste disposal facility means any site or premise used for the accumulation of waste with the purpose of disposing of that waste at that site or on that premises.

Waste management hierarchy is a model that aims to prevent, reduce, and manage waste through encouraging waste avoidance first and then the reduction, reuse, recycling, and disposal of waste and is presented in the form of a pyramid. If the hierarchy is implemented it will assist in the preventing of greenhouse gas emissions, reduces pollutants, save energy, conserves resources, create jobs and stimulate the development of green technologies.

Waste management licence means a licence issued in terms of section 49 of the National Environmental Management: Waste Act 59 of 2008.

Waste to energy is the practice of converting waste to energy.

Executive Summary

Green waste makes up a substantial portion of the organic waste generated in the Western Cape. Organic waste, on the other hand contributes up to 38% of the waste stream in the Western Cape in 2017.[2]. In 2016 the Department of Environmental Affairs and Development Planning (DEA&DP) conducted a status quo analysis[3] on the management of green waste in the Western Cape (WC). This was done to inform the provincial goal of maximising waste diversion from landfill to meet the national organic waste diversion target of 25% by 2019 as per *GNR 636, 2013: National norms and standards for disposal of waste to landfill Regulations*.

The status quo analysis provided a good indication of the poor management and under-utilisation of this waste type as a resource. When one considers that approximately 13% of general waste generated in South Africa is municipal organic waste (DEA, 2012), collected predominantly by municipalities, and an additional 61% industrial and agricultural biomass waste, it is surprising that biological treatment (e.g., composting, anaerobic digestion) is not utilised more extensively in South Africa.[4]

The guideline adopts the principle of green waste as a resource and proposes various environmentally friendly options for its management and beneficiation. Management Techniques and technologies are briefly explored to provide stakeholders in the sector with the required decision-making tools when managing green waste. In some instances, regional solutions are proposed to capitalise on economies of scale and the scarcity of land and resources.

Research was done in sectors generating green or wood waste. These sectors were further researched and unpacked into its subsidiary sectors exploring the various beneficiation options available.

The subsidiary sections covered in the sectors are:

Agriculture:

- Horticulture (flower industry, Nurseries)
- Orchards and Vineyards

[2] GreenCape, 2017. Waste Economy Market Intelligence Report.
[3] DEA&P March 2017. Status Quo Analysis of Green Waste in the Western Cape.
[4] Department of Science and Technology (2014). A National Waste R&D and Innovation Roadmap for South Africa: Phase 2 Waste RDI Roadmap. Trends in waste management and priority waste streams for the Waste RDI Roadmap. Department of Science and Technology: Pretoria

- Cereal

Forestry:

- Paper and pulp industry
- Board manufacturing
- Sawmills
- Commercial Forestry

Kelp/Seaweed

Municipalities:

- Discussions on options for the collection and storage of green waste i.e., collection systems and storage facilities
- The benefits of co-mingling
- PPPs and key aspects that should be incorporated into a green waste contract
- Funding

1. Introduction

The minimisation of waste to landfill is a national and provincial goal, therefore DEA&DP prioritises the diversion of green waste as an 'easy win' option that can lead to significant benefits for both diversion targets and beneficiation opportunities in the forestry, alien clearing and agricultural sectors as well as green waste sources managed by municipalities.

Some of the benefits of diverting green waste:

- Less risk of greenhouse gas emissions.
- job creation.
- soil amendment which increases soil organic carbon levels.
- preventing soil erosion and reducing water use; and
- generate electricity through certain technologies.

The status quo analysis[5] for the management of green waste in the WC revealed the potential for beneficiation opportunities for green waste and the probability of meeting national waste diversion targets. Green waste forms a substantial portion of the municipal waste stream and therefore it is important that the management of it is regulated. Legislation such as *GNR 636, 2013: National norms and standards for disposal of waste to landfill Regulations* requires that 25% diversion from baseline of separated garden waste must take effect within 5 years, and 50% within 10 years, from the date of promulgation (i.e., 2018 and 2023, respectively).

The below figure 1 shows the percentage diversion of green waste per District Municipality and the City of Cape Town. This is based on the data that was available to the Department. This figure may change substantially should more accurately waste related reporting by municipalities takes place.

[5] D: EA&P March 2017. Status Quo Analysis of Green Waste in the Western Cape.

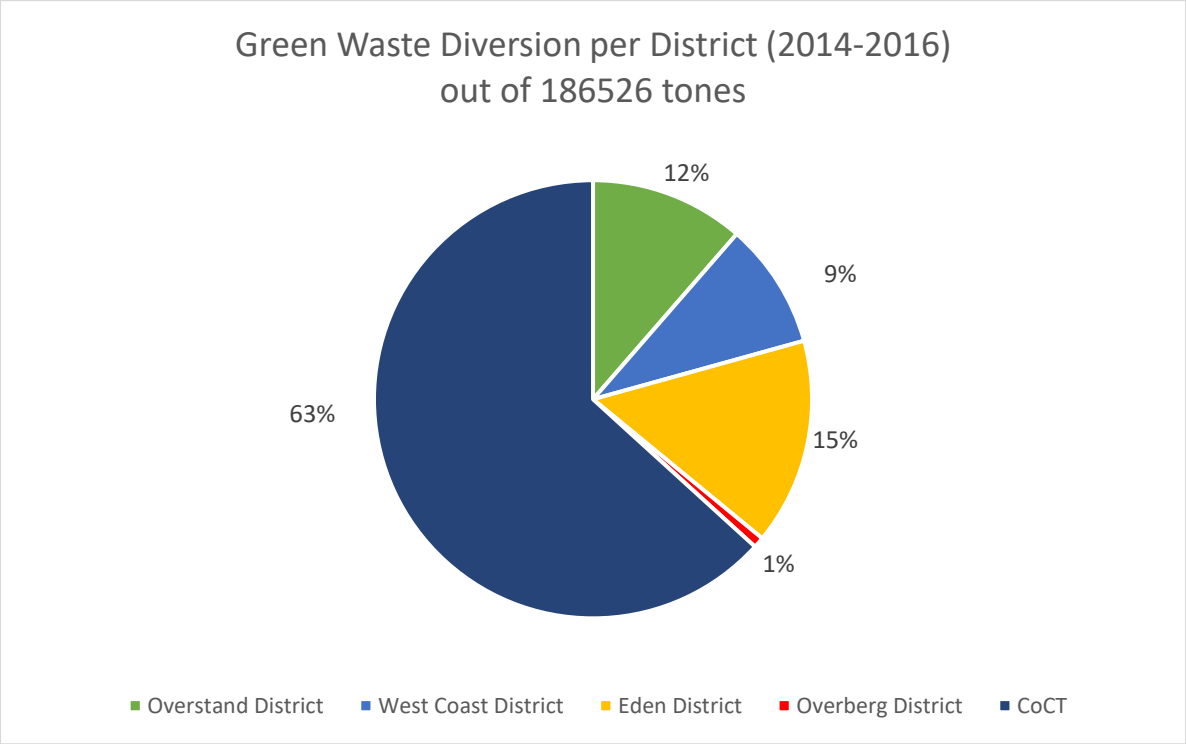


Figure 1: Presentage green waste diversion per District Municipality and the City of Cape Town

Substantial progress has been made in improving waste management in the WC, however the status quo analysis revealed poor quantification systems and inconsistencies in reporting indicating the inaccuracies of green waste disposal data of in the WC is problematic.

The research raised concerns that as much as 16 out of 24 local municipalities dispose of their green waste at Waste Disposal Facilities (WDFs) while most WDFs in the WC are running out of landfill airspace.

There is a growing recognition that recyclable waste and, in this case, green waste, must be viewed as a resource rather than a liability, and hence the focus of the guideline is on bringing awareness to the opportunities to beneficiate green waste so that it is diverted from waste disposal sites.

Research done on the existing generation and management practices of green waste within all municipalities in the WC revealed many challenges. Green waste is derived from a variety of sources such as gardens, sports and recreational areas, forests, invasive alien vegetation and agriculture. Challenges in these areas revealed existing methods are not always effective.

Furthermore, the status quo analysis looked to quantify green waste disposed of at our landfill sites and what was diverted from these disposal facilities.

The guideline addresses key findings of the status quo analysis such as treatment options, sectors generating green waste, and the management of green was in municipalities.

South Africa's legislative environment has changed significantly in the last 16 years in terms of waste management by focusing on waste minimisation and diversion from landfill.[6] The *National Environmental Management Waste Act (No. 59 of 2008)* (NEM: WA) which came into effect on 1 July 2009, requires that waste minimisation be considered by municipalities in addition to municipal services such as cleaning, collection, and disposal to landfill. The National Waste Management Strategy was developed in 2011 as an action plan with the goal of promoting waste minimisation, re-use, recycling, and the recovery of waste that required the development of a strategy for the diversion of green waste from being landfilled by municipalities.

Organic waste is a waste stream of which garden waste form a part of and is recognised as a problematic waste stream nationally and in the WC. The National Organic Waste Composting Strategy: Final Status Quo Report (DEA, 2012) estimated that 20,793,600 tons of organic waste was produced in South Africa in 2011. This equates to about 40% of the total General Waste generated in South Africa (the total being approximately 49,995,029 tons). 'Consider[ing] that approximately 13% of general waste generated in South Africa is municipal organic waste (DEA, 2012), collected predominantly by municipalities, and an additional 61% industrial and agricultural biomass waste, it is surprising that biological treatment (e.g., composting, anaerobic digestion) is not utilised more extensively in South Africa'[7].

Global and local trends indicate that the various components of the waste sector such as waste generators, waste operators, government and civil society are starting to recognise the environmental, economic, and social benefits of taking waste up the waste management hierarchy, to focus on prevention, reuse, recycling, and recovery. Waste streams such as organic waste and recyclables e.g., plastic, metal, glass, paper is targeted globally for diversion.

Although the idea is to take waste up the hierarchy, municipalities must consider implementing technologies and systems that suit their needs. The technology generally used in South Africa for the treatment and recycling of organic waste is composting 'but is not the only technology

[6] The National Organic Waste Composting Strategy: Final Status Quo Report. December 2012

[7] Department of Science and Technology (2014)). A National Waste R&D and Innovation Roadmap for South Africa: Phase 2 Waste RDI Roadmap. Trends in waste management and priority waste streams for the Waste RDI Roadmap. Department of Science and Technology: Pretoria)

that needs to be considered when developing strategies and action plans' to deal with green waste (DEA 2012).

Green waste is a prospective input to a range of technologies used in composting from minimal technologies such as static piles to high technologies such as turned or agitated bays or beds, and anaerobic in-vessel units.[8] These technologies generate output products from lower-grade and high-quality compost, soil conditioner, and biogas. The functionality of soil can be improved through soil conditioners and fertiliser, ensuring healthier food and food security.

Many of these technologies can be operated and managed by municipalities. In the case of medium to high technologies private sector involvement could be required, including the use of private sector technologies.[9]

Barriers and or challenges faced by municipalities that must be unlocked to recover the "maximum value" from waste, in this instance green waste, are financial constraints, legislation limitations, behaviour and or perceptions from the public, lack of information on waste, skills and improved institutionalisation of integrated waste management.[10]

1.1. Strategic Alignment

Table 1 below shows the strategic alignment of this document to various other plans and frameworks.

Table 1: Strategic Alignemnt

Strategies		**Objective**
National Development Plan (NDP)	Environmental Sustainability and Resilience	The absolute reductions in the total volume of waste disposed to landfill each year.

[8] The National Organic Waste Composting Strategy, Final Strategy Report, April 2013

[9] South African Waste Sector – 2012. An analysis of the formal private and public waste sectors in South Africa: A National Waste Research, Development (R&D) and Innovation Roadmap for South Africa: Phase 1: Status Quo

[10] Waste economics - understanding the economics of waste and the financial value of waste as resource presentation by Dr Linda Godfrey Council for Scientific and Industrial Research (CSIR), South Africa

The Medium-Term Strategic Framework 2014 – 2019 (MTSF)		Reflects the national Implementation Framework of the NDP
Western Cape Provincial Strategic Plan (PSP)		Takes it lead from the MTSF
Provincial Transversal Management (2014 – 2019)	Transversal instrument: 3 Strategic goals	• Create opportunities for growth and jobs • Enable a resilient, sustainable quality and inclusive
Cabinet Priority Areas from the PSP	Specific problems and opportunities that need new and innovative solutions through game changers	• Strong growth and jobs • Youth with Hope • Better Living

2. Legislative requirements for the management of green waste

The legislative framework for the management of green waste in South Africa is presented in Table 2. Of particular significance and a strong motivation for the development of this guideline is to facilitate the achievements of targets set for the diversion of green waste from landfill in the National Norms and Standards for disposal of waste to WDFs (23 August 2013). These are:

25% reduction of green waste to landfill in 5 years – 2018; and

50% reduction in green waste to landfill in 10 years – 2023.

Table 2: Legislation framework for the management of Green Waste.

LEGISLATION	SECTIONS RELATING TO GREEN WASTE	IMPLICATIONS ON GREEN WASTE
The National Environmental Management Act, No 107 of 1998 ("NEMA")	Section 24 Environmental Authorizations	In terms of NEMA, it is anticipated that most projects that deals with the processing of waste on large scale would require an Environmental Authorisation ("EA").
	Section 28 (1) Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.	This provision speaks to illegal dumping of any waste or any damage to the environment resulting from the mismanagement of waste.
The National Environmental Management: Waste Act, No. 59 of 2008 ("NEM: WA")	Section 16 General duty in respect of waste management (1) A holder of waste must, within the holder's power, take all reasonable measures to- (a) avoid the generation of waste and where such generation cannot be avoided, to minimise the toxicity and amounts of waste that are generated. (b) reduce, re-use, recycle and recover waste; (c) where waste must be disposed of, ensure that the waste is treated and disposed of in an environmentally sound manner; (d) manage the waste in such a manner that it does not endanger health or the environment or cause a nuisance through noise, odour or visual impacts;	This clause compels any holders of waste to minimize and compels large generators of waste e.g., municipalities to implement waste minimization methods to reduce waste to landfill. It also compels them to manage waste in a manner that does not cause harm to human health or the environment.

LEGISLATION	SECTIONS RELATING TO GREEN WASTE	IMPLICATIONS ON GREEN WASTE
	(e) prevent any employee or any person under his or her supervision from contravening this Act; and (f) prevent the waste from being used for any unauthorised purpose.	
	Section 17 Reduction, re-use, recycling, and recovery of waste (1) Unless otherwise provided for in this Act, any person who undertakes an activity involving the reduction, re-use, recycling, or recovery of waste must, before undertaking that activity, ensure that the reduction, re-use, recycling, or recovery of the waste— (a) uses fewer natural resources than disposal of such waste: and (b) to the extent that it is possible, is less harmful to the environment than the disposal of such waste.	
The National Waste Management Strategy (DEA, 2011)	The National Waste Management Strategy (NWMS Table 3, 2011) places the responsibility (role) on the Municipality (with National and Provincial support in certain cases) to educate, provide vessels (bins), collect, process and dispose (composting facility) of organic waste.	Municipalities must make provision in their IWMP or waste management strategy to manage green waste when generated in large quantities. Clearly defines the roles of the municipality to manage green waste.
the National Waste Information Regulations (13 August 2012, GNR 625, 2012)	Section 5 (1) & (2) deals with the registration of people on the South African Waste Information System ("SAWIS") Section 8 deals with the reporting or submission of information. Annexure 1: List of persons conducting the following activities must register on the SAWI/IPWIS in terms of regulation 5:	All facilities that recover or treat waste over certain thresholds must register and report on the SAWIS/IPWIS.

LEGISLATION	SECTIONS RELATING TO GREEN WASTE	IMPLICATIONS ON GREEN WASTE
	● Recovery or recycling of waste ○ (b), (c) (e) ● Treatment of waste ○ (g) Annexure 2: Reporting requirements in terms of regulation 8 (1) Annexure 3: General Waste types for reporting to the SAWIS, requires the reporting of garden waste as follows: ● Level 1 General Waste types (GW) ● Level 2 Major Waste Type: Organic GW20 ● Level 3 Specific Waste type: Garden Waste (01) ● Garden Waste must be reported under GW2001	
National Norms and Standards for the Disposal of Waste to Landfill (23 August 2013, GG No. 36784 GN No. 636)	Waste Acceptance Criteria for Disposal to Landfill Section 4 (2) Waste listed in section 2(a) of Annexure 1 to the Regulations and destined for disposal to landfill must be disposed of as follows- (iv) Garden waste as per the landfill Disposal Requirements (class B Landfill) Waste Disposal Restrictions Section 5 (1) The following prohibitions and restrictions on the disposal of waste to landfill comes into effect after the timeframes indicated for each waste from the date of the Regulations coming into operation- Waste Prohibited or Restricted in terms of Disposal: (t) Disposal of garden waste (i) 25% diversion from the baseline at a particular landfill of separated garden waste. Compliance timeframe: Five (5) years; (ii)	Green waste must be disposed of at Class B landfill site.

LEGISLATION	SECTIONS RELATING TO GREEN WASTE	IMPLICATIONS ON GREEN WASTE
	50% diversion from the baseline at a particular landfill of separated garden waste. Compliance timeframe: Ten (10) years.	
National Norms and Standards for the Storage of Waste (29 November 2013, GN No. 926)	Section 2 Purpose: (1) The purpose of these norms and standards is to – (a) Provide a uniform national approach relating to the management of waste storage facilities. (b) Ensure best practice in the management of waste storage facilities; and (c) Provide minimum standards for the design and operation of new and existing waste storage facilities. (4) Application (1) These norms and standards apply to any person who stores general or hazardous waste in a waste storage facility. (2) These facilities are required to comply with the norms and standards without a need to conduct a basic assessment and obtain a waste management licence as required by the Government Notice No. 718 of 3 July 2009.	Applies to the storage of waste at facilities.
The National Organic Waste Composting Strategy: Final Strategy Report April 2013	This strategy assists in providing a direction and clear, structured planning towards a common goal *viz.* to ensure (where viable) that organic waste generated within South Africa is diverted from landfill sites. Goal 5: Aims to incorporate composting into municipal planning, responsibilities and create roles for the private sector	Provides guidance for the management of organic waste.
National Norms and Standards for the Sorting, Shredding,	The purpose of the norms and standards is to provide a uniform national approach relating to the management of facilities that	The Norms and standards have a direct bearing on

LEGISLATION	SECTIONS RELATING TO GREEN WASTE	IMPLICATIONS ON GREEN WASTE
grinding, Crushing, Screening, or Baling of General Waste. (No. 243 of 2017)	sort, shred, grind, crush, screen, or bale general waste. The Norms and Standards apply to a waste facility that has an operational area that is 1000m^2, and a facility that has an operational area that is less than 1000m^2 must comply with section 4(4) of the Norms and Standards.	the management of composting facilities.
The National Environmental Management: Air Quality Act (Act no. 39 of 2004), Standards and Regulations	The requirements for the use of biomass in boilers must be adhered to, as required by the 'Declaration of a Small Boiler as a controlled Emitter and Establishment of Emission Standards' (GG No. 831, 1 November 2013).	Applicable for technologies that treat waste especially where any combustion or emission takes place.
Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies act 36 of 1947	Section 7 Sale of fertilizers, farm feeds, agricultural remedies and stock remedies (1) No person shall sell any fertilizer, farm feed, agricultural remedy or stock remedy unless it complies with sub-section (a) – (d), which includes registering under this Act.	The Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (No. 36 of 1947) compels any facility or operation selling compost to be registered with the Department of Agricultural Technical Services.
Regulations regarding Fertilizer (GN No. 250, 23 March 2007)	Annexure A gives the requirements for the registration of fertilizers in South Africa and the general requirements for fertilizers (including compost, municipal compost, sewage sludge, etc.).	Specifies the requirements for composting of green waste.
Draft Norms and Standards for Organic Waste Composting: Notice 68 of 2014, 7 February 2014	The Norms and Standards aim to control the composting of organic waste at a facility that falls within the threshold as described in paragraph 3 of the norms and standards in order to prevent or minimise potential negative impacts on the bio-physical and socio-economic environment. Although the draft norms and standards is not a legal	If these draft norms and standards are promulgated as law and published as such it will compel composting facilities to comply with specifies conditions. The norms and standards

LEGISLATION	SECTIONS RELATING TO GREEN WASTE	IMPLICATIONS ON GREEN WASTE
	requirement it can be used as a guideline for the management of composting facilities.	provide the safe management of the composting of organics to prevent or minimise potential negative impacts on the bio-physical and socio-economic environment during the composting process.
Waste Act: Admission of Guilt Fine Regulations (GN No. R. 635, 24 July 2015)	These Regulations apply only to offences in terms of the Waste Act that relate to general waste and are not applicable to offences that relate to hazardous waste or priority waste	Can be applied for illegal dumping of green waste.
National Water Act (Act 36 of 1998)	Relates to the pollution of a water source and covers aspects such as abstraction, discharge, etc. This Act needs to be considered as part of the site location and any possible water usage as part of the composting process. Composting operations could generate pollutants that need to be managed and prevent pollution of relevant water sources.	Relates to the composting of green waste.

2.1. Specific Legislative Requirements for different treatment options

Table 3: Legislative requirements for the auhtorisation of facilities under the National Environmental Management: Waste Act

Treatment option	***List of waste management activities that have, or are likely to have a detrimental effect on the environment, Government Notice No. 921 of 29 November 2013***

	The following activities will usually be triggered, depending on the capacity the facility can process.
Composting	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)* - ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4)(13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.* - ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*
Waste to Energy	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)* - ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4) (13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.* - ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*
Biochar	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)* - ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4) (13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.* - ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*
Gasification	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)*

	- ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4) (13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.* - ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*
Pyrolysis	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)* - ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4) (13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.* - ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*
Torre Faction	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)* - ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4) (13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.* - ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*
Air Curtain Burners	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)* - ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4) (13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.*

	- ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*
Anaerobic Digestion	- ***Category A (3)(6)*** *"The treatment of general waste using any form of treatment at a facility that has the capacity to process in excess of 10 tons but less than 100 tons. (BA process)* - ***Category A (3)(12)*** *"The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)* - ***Category A (4) (13)*** *"The expansion of a waste management activity listed in Category A or B of this Schedule which does not trigger an additional waste management activity in terms of this Schedule.* - ***Category B (4)(6)*** *"The treatment of general waste in excess of 100 tons per day calculated as a monthly average, using any form of treatment." (S&IER Process)* - ***Category B (4)(10)*** *"The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)"*

It should however also be noted that the following norms and standards may be applicable to the facility:

- ***Norms and Standards for the storage of waste, Government Notice 926 of 29 November 2013:***
- The storage of general waste at a facility that has a capacity to store in excess of 100m^3 of general waste at any one time, excluding the storage of waste in lagoons or temporary storage of such waste.
- The storage of hazardous waste at a facility that has the capacity to store in excess of 80m^3 of hazardous waste at any time, excluding the storage of hazardous waste in lagoons or temporary storage of such waste.
-
- **Norms and Standards for the sorting, shredding, grinding, crushing, screening, or baling of general waste, Government Notice No. 1093 of 11 October 2017:**
- The Norms and Standards apply to a waste facility that has an operational area that is 1000m^2 and more.

Table 4: Legislative requirements for the authorisation of facilities under the National Environmental Management Act

The design of the facility might trigger a listed activity in terms of the EIA Regulations, 2014 it is thus advised that you liaise with the Departments Development Management Directorate on whether the activity is listed by contacting:

Development Management Region 1: West Coast and City of Cape Town municipalities,
Development Management Region 2: Cape Winelands and Overberg District municipalities,
Development Management Region 3: Central Karoo and Eden District municipalities.
Tel: 021 483 4091
Email: enquiries.eadp@westerncape.gov.za
Website: https://www.westerncape.gov.za/eadp

Table 5: Legislative requirements for the authorisation of facilities under the Air Quality Act

Technology	Authorisation requirements
Incineration, air burners, Pyrolysis, Gasification, Biochar, Torre faction	These Technologies must comply with the prescripts of the National Environmental Management: Air Quality Act, 2004 (Act No.39 of 2004): List of activities which result in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage, No 893 November 2013 Category 1 Combustion Installations Category 2 Petroleumgas or biomass. Category 3 Carbonization and coal gasification Category 8 Thermal Treatment of hazardous and general waste
Wood Burning, Drying and the Production of Manufactured Wood Products	Category 9: Pulp and Paper Manufacturing Activities, including By-Products Recovery Subcategory 9.5: Wood Burning, Drying and the Production of Manufactured Wood Product
NB!! Also, the draft norms and standards for the treatment of organics to be considered: National environmental management act (act 107 of 1998), national environmental management: waste act, 2008 (act no. 59 of 2008) and the national environmental management: air quality act (act 39 of 2004) draft national norms and standards for organic waste treatment	

2.2. The waste management hierarchy

In terms of the waste management hierarchy, waste must be managed from the point of generation to the point of disposal through careful control of the following functional elements:

- Waste avoidance (not making waste in the first place)
- Waste minimization (reducing waste, reusing, sorting, and recycling)
- Generation (when waste is made)
- On-site storage (where waste is stored temporarily when it is first produced)
- Collection (how waste is picked up)
- Transport and Transfer (how waste is moved)

- Processing and materials recovery (how waste is treated or made useful)
- Disposal (how waste is finally discarded)

NB: Waste can be converted into biofuel and/or other types of renewable energy.

3. Provincial position on organics

- Targets should be set for the diversion of organic waste from landfill. Currently targets are set for the green waste portion of organic waste only. (25% diversion from baseline of separated garden waste, and 50% within next 10 years (i.e. 2018 and 2023, respectively)).
-
- That efforts should be made to reduce unnecessary regulatory obstacles and to consider alternative mechanisms such as norms and standards.
- That infrastructure and technologies for diversion and beneficiation should be supported.
- That regionalisation and collaborative approaches should be taken with regards to organic waste minimisation in the Western Cape.
- There is insufficient knowledge thus far of the cost to benefit ratio and feasibility of many of the technologies.
- Furthermore, it is vital that solutions are guided by what makes local and economic sense, based on
    - amongst others, the quantities and types of organic waste generated and available
    - the local cost of technology solutions
    - the value of waste streams to local markets
    - available skills
    - the local policy environment
    - and the local climate for business and investment

4. Overview of key findings of the Green Waste Status Quo Report[11]

The findings of the Green Waste Status quo report can be summarised into three separate areas. These were the sources of green waste, the diversion of green waste at municipalities and the conclusions made from the findings. These will be unpacked below.

The sources of green waste were found to be:

- Forestry
- Invasive
- Alien Vegetation
- Agriculture
- Kelp
- Public Gardens
- Household gardens
- Landscapes

Not all of the municipalities record their Green Waste received at their waste disposal facilities, Figure 2 shows which municipalities (excluding the CoCT) record and report on green waste generated per annum between 2014 and 2016 where available. Figure 3 includes the CoCT and shows the magnitude of generation in relation to the rest of the province. The CoCT also maintains accurate records of green waste generation.

[11] DEA&DP March 2017. Status Quo analysis of Green Waste in the Western Cape.

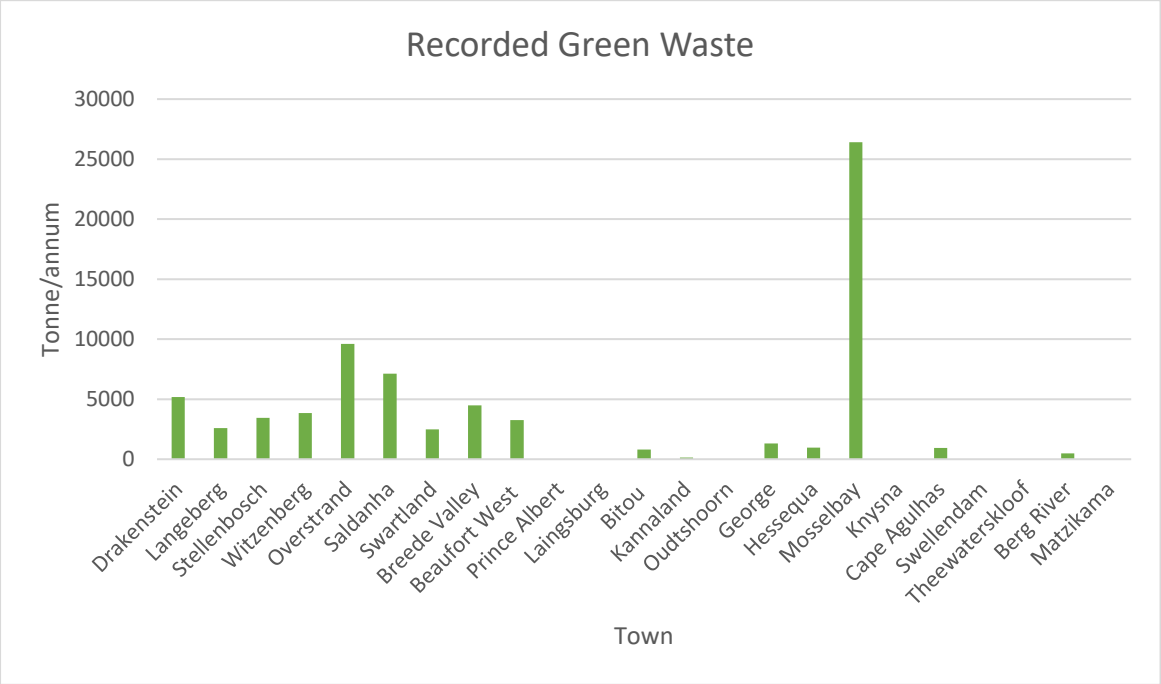


Figure 2: Recorded Green Waste within Municipalities

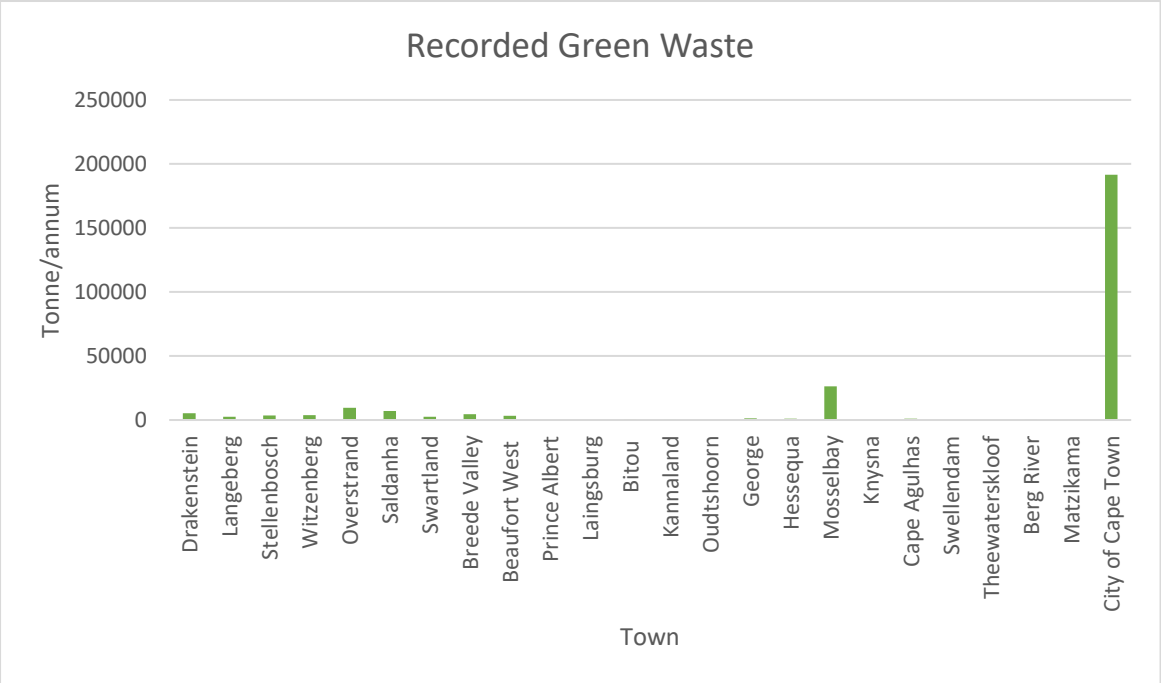


Figure 3: Recorded Green Waste within Municipalities including the City of Cape Town

Municipalities currently report green waste to IPWIS under organics which includes garden, wood and food waste. The National Information Regulations, 2012 provides for organics to be reported as GW20 and then split into GW2001 (Garden Waste), GW2002 (Food Waste) and

GW203 (Wood Waste), but currently it is not being reported to this level. Furthermore, municipalities do not monitor green waste quantities generated by private companies.

Various methods for managing green waste are employed in the Western Cape. Green waste generated within a municipality will be sent to the following facilities if it is not diverted for another purpose or if it is illegally dumped.

a) drop-off facilities where green waste is chipped and sold as mulch or used in the composting process.
b) transfer station where green waste may be chipped and transported for further processing.
c) disposal sites where green waste are landfilled or used as cover material.
d) waste to energy facilities (See Table 6)

Green waste as a diversion option has significant benefits (GreenCape: 2017) amongst others;

- Moving away from the reliance on landfilling of green waste saving valuable airspace.
- Decreases the carbon footprint and methane generation on landfill sites.
- It has the potential to contribute to the green economy.
- Creation of sustainable jobs.
- Produce beneficial soil amendments such as composts and fertilizers.
- Prevent soil erosion and reducing water use for growing plants and crops.
- Recovery technologies provide alternative options for the generation of electricity, production of heat for industrial purposes and the generation of other fuels for secondary energy production.

Green waste is a prospective input to a range of beneficiation technologies ranging from low tech options more suited for the municipalities to more advanced technologies that require high capital investments and hence best suited for the private sector. Barriers and/ or challenges faced by municipalities to "maximise the value" from waste are:

- financial constraints;
- Restrictive legislation;
- behaviour and or perceptions from the public;
- lack of information on waste;
- limited skills; and
- institutionalisation of integrated waste management.

The impending ban of organics from being landfilled as stipulated in the NEMWA: National Waste Classification Regulations means that an enabling environment must be created within the municipal space to ensure the uptake of green waste in a manner that maximises the beneficiation thereof. It is imperative that opportunities for exposure to technologies and opportunities to engage with these technology owners are created. In this way municipalities and other stakeholders can make informed decisions about the most appropriate options available to them.

5. Treatment options for the management of green waste

There are several treatment options available for green waste management these range from different types of composting to Torrefaction. All of these options will be discussed below.

5.1. Composting

The National Waste Management Strategy (NWMS) (2011) was established to enable the implementation of the NEM:WA and to encourage composting as one of a number of methods to realizing the objectives of the waste management hierarchy. The Department of Environmental Affairs (DEA) then initiated The National Organic Waste Composting Strategy (NOWCS) with the aim to develop and promote the diversion of organic waste from landfill sites for soil beneficiation and other uses through composting.

The composting of green waste, a fraction of organic waste stream, has been a proven method of organic waste minimisation with proven local and international practices proving the effectiveness of composting organic waste. Composting contributes to the diversion of green waste from being landfilled and helps in the reduction of landfill gas.

Because green waste makes a huge contribution to the total general waste generated in South Africa (i.e. up to 24% by mass[12]), composting has a huge potential in South Africa and therefore was investigated as a diversion alternative.[13]

[12] Department of Environmental Affairs, 2012 Department of Environmental Affairs 2012. Draft Waste Classification and Management Regulations, Notice 613- 615 of 2012. Pretoria.
[13] The national organic waste composting strategy, Final Strategy Report: April 2013

An important factor to remember when composting is the saying "Rubbish in - Rubbish out." "All composting systems are limited by the nature of the raw materials they process. Poor quality starting materials makes poor quality compost".[14]

Although there are many advantages of composting, it also has its disadvantages. See table 6.

Table 6: Advantages and Disadvantages of composting

Advantages of green waste composting[15]	**Disadvantages of green waste composting**
• Composting of Green waste produces fairly hygienic products and is viewed as an environmentally friendly method.	• The duration required for composting is time consuming, requires space and need for manpower.
• During the incubation process the high temperatures destroys pathogenic organisms.	• As it contains only limited levels of plant nutrients compost is a soil emendation, not a fertilizer.
• Composting is a method that can process all green waste.	• The cost of equipment.
• Large quantities of green waste can be managed in a sustainable matter.	• The challenge of augmenting a successful marketing plan for compost.
• Compost provide an opportunity for organic matter and nutrients to return to the natural cycle through the application of compost to the soil.	• Green waste that has been exposed to heavy pesticides, heavy metals in high concentrations can result in compost that is undesirable for land application.
• Compost increases the activity of earthworms and other natural soil organisms beneficial for plant growth	

[14] Introduction to Composting Science and Management for Industry Training: An overview of the scientific principles of the composting process. Compost New Zealand, 2007

[15] Green Waste as a Resource for Value Added Product Generation: A Review. Vivek P. Bhange, SPM. Prince William, A.N. Vaidya, A.R. Chokhandre

5.1.1. Legislation relating to composting in South Africa

Composters only need to comply with the requirements of the *Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947)* or the *Regulations Regarding Fertilizers GN No. R. 250 of 23 March 2007* when the composter aim to sell the compost they produce as a fertilizer.

The product must meet the following requirements before it can be sold:

- it must be sold in containers and must be fine enough for 100% thereof to pass through a 12mm standard sieve;
- it must be a household and garden fertilizer as defined in the Regulations;
- the ash content thereof does not exceed 670g/kg on a dry mass basis;
- the moisture content does not exceed 400g/kg;
- it does not contain any visibly undecomposed organic or other foreign material; and
- at least 80% of seeds that are planted under controlled conditions germinate normally and exhibit normal growth when planted in a growth medium as prescribed by the holder of the registration or manufacturer of such fertilizer.[16]

5.1.2. The Basic Composting Steps

Table 7: Basic composting steps

Composting Basics		
Particle Size	Grinding, chipping, and shredding materials increases the surface area on which microorganisms can feed as well as producing a more homogeneous compost mixture and improving pile insulation. *If the particles are too small, however, they might prevent air from flowing freely through the pile.	 http://www.charliestreeservice.com.au/Charlies_Tree_Service/Wood_%26_Green_Waste.html
Moisture Content	 http://agriculture.vic.gov.au/agriculture/farm-management/recycling-and-waste-management/composting-spoiled-hay	Microorganisms living in a compost pile need enough moisture to survive. Water is the key element that helps transports substances within the compost pile and makes the nutrients in organic material accessible to the microbes. Organic material contains some moisture in varying amounts, but moisture also might come in the form of rainfall or intentional watering

[16] The national organic waste composting strategy, Final Strategy Report: April 2013

Oxygen Flow	Turning the pile, placing the pile on a series of pipes, or including bulking agents such as wood chips and shredded newspaper all help aerate the pile. Aerating the pile allows decomposition to occur at a faster rate than anaerobic conditions. Care must be taken, however, not to provide too much oxygen, which can dry out the pile and impede the composting process.	http://agriculture.vic.gov.au/agriculture/farm-management/recycling-and-waste-management/composting-spoiled-hay
Temperature	http://www.compost-systems.com/en/green/messtechnik/temperaturmessung	Microorganisms require a certain temperature range for optimal activity as certain temperatures promote rapid composting and destroy pathogens and weed seeds. Microbial activity can raise the temperature of the pile's core to at least 60° C. If the temperature does not increase, anaerobic conditions (i.e., rotting) occur.
Things to think about	- Creating compost can take up to two years, but manual turning can speed up the process to between three to six months. - Compost should not be used as potting soil for houseplants due to the presence of weed and grass seeds. - "Grasscycling" is when you leave your grass clippings on the lawn to naturally decompose. This naturally return some nutrients back into the soil and is similar to composting. - Leaves can be used as mulch around trees and shrubs to retain moisture	

(United States Environmental Protection Agency, 2016)

5.2. Waste to Energy

Table 8: Waste to energy facilities in the Province

Waste2Energy facilities[17]	
City of Cape Town	
FairCape Biogas Digester & associated infrastructure, Kuiperskraal (AD)	Animal manure, yoghurt, milk returns and wastewater from Fair Cape Factory
Farmsecure Energy: Anaerobic Biodigestion Facility NEW HORIZONS	Residential, commercial and industrial waste. Specific organic waste not defined
Keibees Piggery and Zandam Cheese, Anaerobic digester for electricity generation	Only animal waste from Keibees and Zandam farms

[17] DEADP 2017. Guideline on the Management of Abattoir Waste in the Western Cape.

Astral / County Fair Facility for onsite treatment & use of poultry litter	Chicken manure and wood shavings
West Coast District	
Cape Dairy Biogas	Animal manure
Biogas Development (AD Facility Saldanha Steel)	Residential, commercial and industrial waste. Specific organic waste not defined
FSC Darling Road Biogas Renewable Energy Project	Animal manure
Cape Winelands	
FSC Bonnievale Biogas Renewable Energy Project (AD)	Animal Manure
Overberg District	
Elgin Fruit Juices Anaerobic Digester	Permissible waste excludes green waste

5.2.1. Biochar

The International Biochar Initiative defines biochar as being the product of thermal decomposition of organic material under limited oxygen supply, and at relatively low temperatures. Biochar can however be simply defined as charcoal used for agricultural purposes (Biochar.info, n.d.). The process is called thermal decomposition and it is usually in the form of pyrolysis or gasification (International Biochar Initiative, n.d.). Each have a variety of options in regards to equipment which can be as simple as a campfire or as complex as a bio-refinery (International Biochar Initiative, n.d.). Pyrolysis and gasification are discussed in sections 5.2.3 and 5.2.2 separately. It is primarily used to enhance soil fertility by reducing leaching of nitrogen, moderating soil acidity, increasing water retention and more. There are however limitations such as possible yield decline, heavy metal contamination associated with it as well (International Biochar Initiative, n.d.; Six, 2014). Below is a table indicating some of the benefits and limitations of biochar:

Table 9: Benefits and limiations related to biochar *(Six, 2014)*

Benefits and limitations of using Biochar	
Benefits	**Limitations**

Increased yields of up to a doubling.	In some cases, yields may decline because of the sorption of water and nutrients by the biochar, which reduces the availability of these resources for the crops. Biochar has also been shown to inhibit germination.
Increased fertilizer efficiency.	The sorption of pesticides and herbicides by the biochar can reduce their efficacy.
Increased water quality due to retention of pollutants, such as pesticides, herbicides, nitrate, phosphate, heavy metals, etc.	Some biochars can act as a source of contaminants, such as heavy metals, VOCs (Volatile Organic Compounds), PAHs (Polycyclic Aromatic Hydrocarbons), and DOC (Dissolved Organic Carbon).
Mitigation of climate change due to the sequestration of carbon in a resistant form, the reduction of the emissions of the potent greenhouse gases nitrous oxide and methane, production of renewable energy, etc.	The reduction in nitrous oxide emissions is not universal and emissions even increase sometimes.
Decreased ammonium emissions	The fine ash associated with biochar is the perfect source for dust, posing a risk for respiratory diseases.
Disposal of green waste from agriculture and forestry.	Long-term removal of crop residues, like stems, leaves and seed pods, to be used for production of biochar can reduce overall soil health by diminishing the number of soil microorganisms and disrupting internal nutrient cycling.
Increased cation exchange capacity of the soil.	The increase in cation exchange capacity depends on the composition of the soil: it is minimal in soils with high clay or organic matter content, especially at realistic rates of biochar additions.
Increased soil moisture.	In high pH (alkaline) soils, an increase in soil pH is not desirable as crops only tolerate a certain range of soil pH.
Increased soil pH (i.e. less acidic)	
Increased soil microbial biomass	

5.2.2. Gasification

Gasification can be simply described as an incomplete combustion. It is a flexible, reliable and commercial technology which can turn a range of low value feedstock into high value products (Gasification & Syngas Technologies Council, n.d.). The process consists of burning a solid fuel without allowing enough air for it to complete combustion. As such the output material still has combustion potential. Gasification produces biochar, bio-oil and syngas, though gasification tends to produce less biochar than pyrolysis (All Power Labs, n.d.).

A growing number of countries are turning to gasification because the method is environmentally friendly and turns energy into a variety of useful products such as the ones mentioned above.

Case study 1: SENFORE Gasification Technologies

SENFORE is a company that created their own fast gasification and carbonization technology. A telephonic interview was also conducted with Luke Boshier and according to him, the technology is currently using alien biomass and sawmill residual but can run on any waste types such as human waste to plastic and tyres, alien invasive vegetation, agro-waste in all forms, rubber, tires, plastics, medical waste, garden refuse and even solid sludge from sewerage works.

The technologies offer both normal Pyrolysis/carbon Cracking (Eco Creation manufactured) for selected waste streams of plastics, tires, rubber and bunker type oils, fast Gasification process for a broader range of waste streams such as municipal waste.

This new technology converts the feedstock material into carbon in the open- to- air, fast pyrolysis

According to SENFORE, a normal gasification method that uses pyrolysis is based on the supply of heat to materials in an atmosphere starved of oxygen/air. This will result in the pyrolysis or gasification of the materials. However, in oxygen starved environments the process takes a very long time and if the oxygen/air supply is increased to speed up the process, then combustion takes place and a high level of ash is the result with many emissions.

SENFORE technologies uses a process called updraft gasification and is open to air, meaning it is very safe to use and does not release any harmful emissions to the outside environment.

The SENFORE Technologies process utilizes the natural phenomena known as Flame Propulsion Speed (FPS), to change the normal combustion reaction, while still exposing the material to temperatures required achieving complete pyrolysis/gasification and carbonization. This method is based on forced induction and circulation of high temperature gas/air mixture through the materials that are utilized as feedstock. This process heats the gas mixture to a temperature high enough to achieve complete pyrolysis and gasification without combustion and therefore "no emissions generated"

5.2.3. Pyrolysis (Direct Combustion: in a boiler/wood fired boilers)

Pyrolysis is the breakdown of waste with heat and no additional oxygen. Temperatures used for effective pyrolysis can be lower than incineration and ranges from 300°C - 500°C. These temperatures ensure that the hydrocarbon content of the waste feed reacts and generates various products like syngas, pyrolysis oils, electricity/heat, feedstock for chemical industry, bottom ash, char or slag and fly ash, depending on what material was used as waste feed. Waste such as glass, metal and any other inert waste like rubble are generally not ideal for pyrolysis, hence the importance of implementing the waste hierarchy, specifically waste minimisation before rendering an item to this system. The need for this process to be without additional air or oxygen means that the process is extremely controlled.

The process is based on a rotary kiln. When the waste arrives at the site, it undergoes sorting and pre-treatment. A rotary kiln reactor is then filled with the waste feed. The gas given off is then cooled and the pyrolysis oil is condensed and collected in drums. The oils then serve as furnace fuel or used for diesel generators. Energy derived from non-condensed gases heats up the system and generates steam. The steam is used to run turbines to generate electricity. However, the residues such as inert mineral ash, inorganic compounds and unreformed 168 carbons, generated during the process of pyrolysis are toxic. These plants are highly dependent on the numbers in feedstock available, in order to work effectively. The flexibility of these plants makes it easy to operate though.

Advantages:

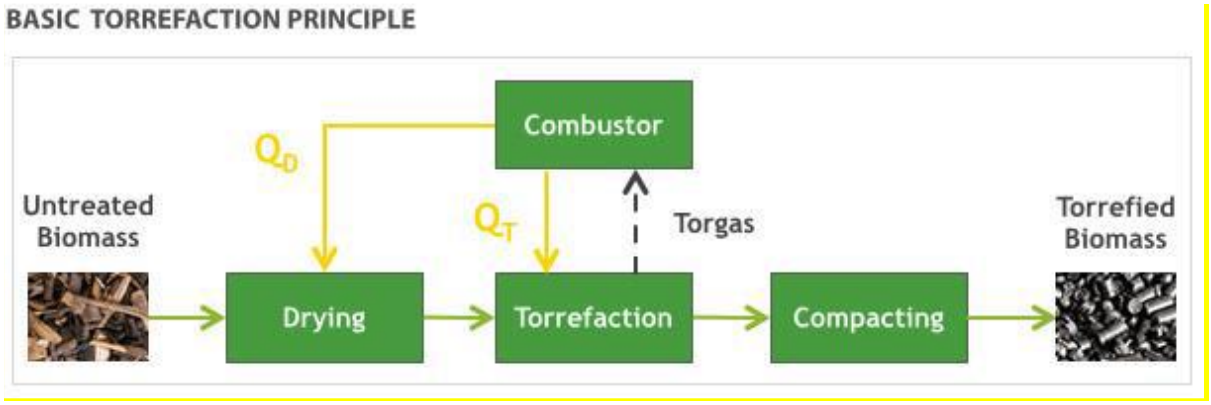
- The emissions generated by the process are fewer, due to the limited use of oxygen, so these emissions are easier to control through scrubbers which remove contaminants.

- Pyrolysis produces more useful products for various applications. For example, gases, oils and solid char produced from pyrolysis can be used as a fuel, or purified and used as a feedstock for petro-chemicals and other applications.
- Pyrolysis reduces climate change by replacing coal and natural gas as a viable fuel.

5.2.4. Torrefaction (to increase energy density)

Torrefaction is a thermochemical treatment process similar to roasting or mild pyrolysis (Dutta & Leon, n.d.). The objective of the thermal process to convert biomass (wood, grain, etc.) into a coal-like material, called torrefied biomass or bio-coal, which has better fuel characteristics than the original biomass. The end product is a stable, homogeneous, high quality, solid biofuel with far greater energy density and calorific value than the original feedstock, providing significant benefits in logistics, handling and storage, as well as opening up a wide range of potential uses (Blackwood Technology, n.d.). It should be noted that torrefaction alone does not significantly increase energy density, but allows material to be more easily pelletized or briquetted. As such, it is typically combined with densification techniques (pelletizing and briquetting) to further increase energy density (Dutta & Leon, n.d.) (Clarke & Preto, 2015).

The process involves the heating of biomass in the absence of oxygen to a temperature of about 200 to 320°C for up to 30 minutes (Dutta & Leon, n.d.). During the torrefaction process a combustible gas is released, which is combusted to provide the thermal energy required for both drying and the torrefaction process. Eventually this is assisted by an auxiliary fuel, but in a properly designed and operated torrefaction system, the energy contained in the torrefaction gases may be sufficient to sustain both the drying process and the torrefaction process. This however strongly depends on the moisture content of the incoming biomass and the required degree of torrefaction (Cremers, et al., 2015) (Blackwood Technology, n.d.).



Source: Blackwood Technology, The Netherlands, The Netherlands

Figure 4: Basic Torrefaction Principle

Advantages

Torrefaction improves the physical characteristics of biomass, and thus the overall economics of the biomass utilization process for energy production. As such, torrefaction results in:

- Higher energy content per unit volume and lower moisture content.
- Makes biomass hydrophobic (making transport, handling and storage less expensive and easier),
- Lengthens storage life,
- Has higher yields during gasification,
- Better grindability,
- Removes smoke compounds,
- Improves friability,
- Is cleaner than burning the input products normally,
- Allows sourcing of different types of woody biomass and delivers a single homogeneous fuel, and
- Significantly decreases emissions and reduces overall energy & operating costs when blended with fossil fuels (Aeon, n.d.) (Laryea-Goldsmith & Woolard, 2013).

Disadvantages

- The volume of torrefied biomass is reduced only slightly, ~ 10-20% lower than the dried feedstock,
- Despite the higher calorific values, energy density is not improved significantly (~5GJ/m3),
- Although small, some of the energy content in original biomass is lost (~10%),
- Does not reduce corrosive deposits on boiler tubes (all ash components of biomass are still present in torrefied biomass),
- There is limited knowledge on process performance, properties of torrefied product and composition of volatiles (Dutta & Leon, n.d.).

5.2.5. Air curtain burners

Air curtain burners are mobile incinerators, a new concept to SA. It follows international trends in dealing with Biomass and Wood waste. The cost (in SA) would be approx. R30,000 per day

to hire the machine, which can deal with 80-100 tonnes of biomass per day. The technology has been used internationally for approx. 5-10 years (includes Australia, Indonesia, California, Japan, Europe) and complies with EU standards.

[18]Figure 5: Air Curtain Burners (Gabbert, 2013)

How it works:
Wood waste is placed into walled burn chambers with a fuel.

Air Curtain Burners above ground refractory walled burn chambers ensure a high velocity curtain of air over the top of the burn chamber. The purpose of the air curtain is to form a lid over the burning mass trapping particulate matter that rises along with intense hot gasses. The particulate matter is re-burnt until the particles are so small they escape as a gas through the air curtain. Particulate matter is what is generally referred to as smoke.

High temperatures of 800 to 1200 degrees Celsius are reached in air curtain burners. This means an almost comprehensive combustion of wood and green waste.

5.2.6. Anaerobic Digestion (Biogas)

Anaerobic digestion refers to a number of biological processes where biodegradable material is broken down by microorganisms in the absence of oxygen. A very useful end product from these processes are biogas, when combusted it generates electricity and heat. Furthermore,

[18] http://myemail.constantcontact.com/USBI-Biochar-2016--Conference-News-and-Updates.html?soid=1124199130091&aid=F1QzWqaJM_w

it can be processed into transportation fuels and a renewable natural gas. There are 4 biochemical processes involved in this process, and they occur partly at the same time, the processes are described below:

Table 10: The Biochemical processes of Anaerobic Digestion

Hydrolysis	The process is slow and involves complex organic material being transformed to polymers and monomers that are liquefied by bacteria.
Acidegonesis	Amino acids and sugars are altered to ethanol and acids leading to ammonia being produced.
Acetogenesis	Hydrogen, carbon dioxide and acetic acids are formed after substances are transformed.
Methanogenesis	The Methanogenic bacteria are involved in changing the acetic acid and hydrogen into methane gas and carbon dioxide.

The process starts when the bio-degradable material for an example animal waste is put into a digester which is typically a tank that must be tightly and carefully closed so that no oxygen can get inside; the material is then broken down by bacteria that occur naturally, and after the decomposition is done methane is produced. The produced methane is used to generate electricity but it is not limited to that, it can also be used for road vehicles.

All kinds of organic waste can be used by the technology such as yard waste (grass, leaves, and branches) except for trees because they decompose slowly.

An example of an Anaerobic Digestion System in London is shown in figure 6 below:

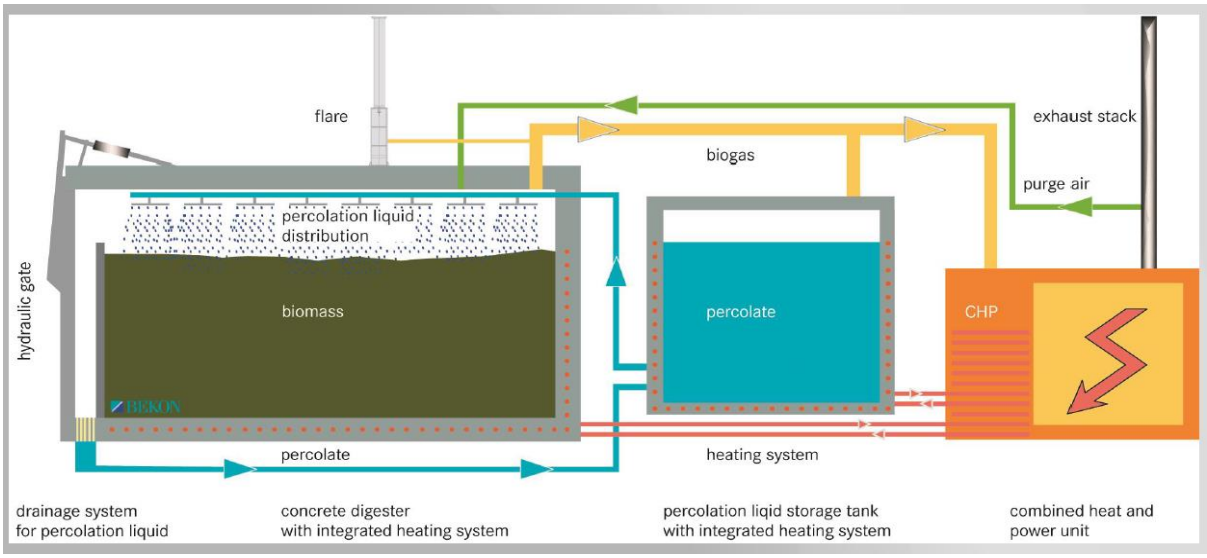


Figure 6: Example of an Anaerobic Digestion System

Source: ***Tamar Energy Limited, London***

End products: heat/electricity (Biogas), fertilizer

Types of biogas installations in South Africa (Domestic/residential digesters)

- PVC digester
- Concrete digester
- Plastic bag (biobag digester)

Table 11: Benefits and Limitations of using Anaerobic Digestion

Benefits and limitations for using Anaerobic Digestion	
Benefits	**Limitations**
The process sterilises pathogens and are removed from the waste.	Anaerobic digestion process is slow and sensitive.
Process helps minimises the odour being released.	It is a complicated process it therefore needs staff that are well trained.
Disposal costs avoided as waste is decomposed and diverted from landfill.	Significant pre-processing of municipal waste may be required to ensure smooth process operation.
Renewable energy is produced which reduces the need to harvest fossil fuels for energy.	Treats only the organic fraction of municipal waste.

Benefits and limitations for using Anaerobic Digestion	
Waste is used as a resource; value is recovered from waste.	Possible odour releases during materials handling.
Reduces global warming because the greenhouse gases captured are used to produce energy.	Small- and middle-scale anaerobic technology for the treatment of solid waste in middle- and low-income countries is still relatively new.
Produces useful end products, the nutrient rich digestate will be used to condition and fertilise the soil and Biogas for energy as mentioned above.	Digestates often contaminated if treating municipal waste, leading to difficulties in usage.

End products- heat/electricity (Biogas), fertilizer

Environmental and legal compliance

Installation of anaerobic digestion systems requires environmental authorisation as it triggers multiple environmental regulations (NEM: WA, NEMA, NWA and NEM: AQ).

Economic benefits for using Anaerobic Digestion

Case study 1

Landfills will be a little lighter in the Cape with a new biogas plant set to open in Athlone.

A new biogas plant has opened in Athlone which is situated in Cape Town. This new waste-to-energy plant will focus on converting organic waste into useable bio-methane which will be used to create products such as liquid carbon dioxide, organic fertiliser and compressed biomethane (Naidoo, 2017). The gas will be marketed as an alternative to Liquefied Petroleum Gas ("LPG") and diesel, and the carbon dioxide will be used in industry, agriculture and waste-water treatment. The liquid carbon dioxide extracted from organic waste is currently used by Coca-Cola Enterprise as it is added in their manufactured carbonated soft drinks (Chen et al, 2006). The new venture will be undertaken by Gas Company Afrox and New Horizons Energy.

Cost, jobs and partnerships

New Horizons Energy CEO Egmond Ottermann said the plant will cost around R400-million, with 60% of the plant being financed by the Industrial Development Corporation (IDC), and is expected to create 80 full-time jobs (Naidoo, 2017). According to Naidoo (2017), the CEO of New Horizons Energy made a partnership with Waste Mart which has agreed to deliver more than 500 tonnes of organic household, municipal and industrial waste to the plant every month. Afrox will use the compressed bio-methane and distribute it to its customers as an alternative to LPG or diesel.

Bio-methane gains popularity

Going green has gained much popularity globally. As a result, bio-methane was identified as a product that could serve as an alternative to existing polluting fuels that are used to generate electricity or are used in a range heating processes. "There's great potential for making products such as plastic bricks and roof tiles," Ottermann told Engineering News. "We expect many littler industries to be established close to the plant so that we can drive zero waste to landfill." Afrox marketing manager Heinrich Uytenbogaardt said there was a "relatively underdeveloped market in South Africa, and in Cape Town in particular" for natural gas and that it was widely used around the world.

Case study 2

Working with Coca-Cola Enterprises to improve environmental sustainability

Since 2011, Aqua Enviro – innovative leaders in the fields of water, wastewater, bio-solids and organic waste, has provided technical expertise which has enabled Coca-Cola Enterprises to reduce its carbon footprint, save on utility costs and create renewable energy on site. Coca-Cola Enterprises has used anaerobic digestion technology to treat liquid waste effluent at its manufacturing Wakefield site since 1989, being one of the first to pioneer this technology.

The Wakefield site is the largest soft drinks plant by volume in Europe and can produce 6,000 cans of soft drink every minute, creating approximately 100 cans per second. The anaerobic digestion plant now reduces the 'strength' of effluent by up to 90% before it is discharged, a process that significantly reduces demand on the municipal wastewater treatment works, enabling cost savings for Coca-Cola Enterprises. The facility treats sugar, fruit products and other waste materials within the effluent. Biogas is then produced from the anaerobic digestion process, collected and used in biogas boilers, this renewable energy source displaces natural gas which would otherwise be required.

5.2.7. Co-mingled options for the processing of green waste with other organics

There are a few technologies that can combine green waste with organic waste. This is especially helpful in cases where there isn't enough green waste to use a technology or when organic waste is identified as a problem in an area. Following is a table indicating options for co-mingling green waste with other organics:

Table 12: Technologies which allow the co-mingling of green waste with organic waste

Technique	Waste types
Incineration	Green waste, organic waste, Paper, Tyres, Plastics
Pyrolysis	Green waste, organic waste, Paper, Tyres, Plastics
Gasification	Green waste, organic waste, Paper, Tyres, Plastics
Anaerobic Digestion	Green waste & organic waste
Aerobic Digestion	Green waste & organic waste

(DEA&DP, 2015)

5.3. Fires

General information on possibility of fires:

Waste to energy plants and the composting process are at risk of fires due to commonly used fuels from waste streams such as wood waste, organic biomass such as green waste, dried sewerage sludge, used tyres, municipal solid waste collection etc. One of the risks these waste fuel streams present is 'spontaneous combustion.'[19]

Important legislation to be considered in the design of facilities:

- National Building Regulations and Building Standard Act, Act 103 of 977
- National Building Regulations department of trade and industry No. R. 2378 12 October 1990
- The National Building Regulations and Building Standards Act, 1977 commencement of the national building regulations No. R. 432 8 March 1991
- National Building Regulations and Building Standards Act,1977 (Act 103 of 1977) National Building Regulations No. R. 574 30 May 2008

[19] Fires in waste to energy power generation plants. A guide to loss prevention. HSB Engineering Insurance. Munich RE

- Municipality may issue by-laws in terms of the Local Government Municipal Systems Act 32, 2000. Not all municipalities have fire by-laws

The management of waste to energy plants must take into consideration for the control of a fire risk the following hierarchy:

Fire separation – the use of fire doors, fire dampers, fire shutters and fire windows according to local building regulation and standards e.g., SANS 10139 'Fire detection and alarm systems for buildings.

Fire prevention – The security of the facility must provide restrict access control to ensure wrong doers who plan to commit malicious damage to property, theft, or arson. Adherence to the fire plan by staff and continued awareness with staff regarding the risk of fires.

Fire detection - All rooms within all buildings should be fitted with an automatic fire detection and alarm system

Fire extinguishing – water availability must be from a reliable source and should be able to provide water for at least 2 hours.

Fire protection for specific areas of plant must be considered. Waste to energy power generating plants operate using fuels and include process and equipment areas that require specific fire protection and design to minimise fire risks.[20]

The above risk control measures must be built into design and management procedures implemented by power generation plants.

Fires at composting facilities are a common phenomenon and remains a problem for facility managers. Usually, operators recognise and contain fires without a great deal of damage or publicity.

Risk factors in composting is the spontaneous combustion fires started when microbial activity heats up the pile. Key conditions for spontaneous combustions are biological activity, relatively dry materials, dry pockets in piles, limited air flow.

A small fire might threaten to attract public interest towards the potential risks and potential nuisance of composting activities at a particular facility, but a major fire threatens asset and is a potential danger to staff and those fighting the fire. Considering this it becomes very

[20] [20] Fires in waste to energy power generation plants. A guide to loss prevention. HSB Engineering Insurance. Munich RE

important for facility managers to understand how fires start and how they must be managed in the presence of large volumes of organic waste.[21] Compost fires can be started by lightning strikes[22], heat from equipment, sparks from welding, cigarette butts, wildfires, arson and spontaneous combustion.

During the operational phase of a composting facility the management of such a facility must adhere to the National Norms and Standards for Composting. Section 6 (4) addresses fire and methane gas management and requires a facility to have a fire management plan or strategy.

For the management of compost pile see **Annexure A**.

The management of the storage of waste fuel at facilities must form part of the fire plan. Depending on the type of waste fuel, 'fires can be deep seated and difficult to extinguish quickly'.[23]

In processes such as pyrolysis where methane gas is generated facility design plays an important role to avoid explosions caused by such gas.

It is important that incidences are recorded. Data collection and its statistical analysis will assist fire brigade services to improve their response and performance. It can also help them focus on fire prevention programs linked with specific challenges experienced at waste to energy and composting facilities. Data can also reveal tendencies in system failure.

Finally, fires can be started by people and proper steps should be taken to make sure that the public cannot enter the facility and set fires to any stockpiles.

Sectors generating green or wood waste

The following sectors will now be discussed in turn, Agriculture, Forestry, Alien Clearing and Municipalities.

[21] Fires at composting facilities causes and conditions (part 1,) Robert Rynk
[22] Compost fires, Jim Lapp, Canadian representative Swana https://swananorthernlights.org/wp-content/uploads/2015/03/2C-Jim-LappCompost-Fires.pdf
[23] Fires in waste to energy power generation plants. A guide to loss prevention. HSB Engineering Insurance. Munich RE

6. Agriculture

6.1. Overview of challenges in the sector

The agricultural sector produces the largest amount of waste generated in the Western Cape. Last year the industry produced 2 million tonnes of agricultural waste with 28% of the Province's waste belonging to the category according to Green Cape in their latest Waste Economy: Market Intelligence Report (GreenCape, 2017). Although this raises some concern, it also brings to light potential opportunities regarding green waste for the sector. These opportunities will not only assist in job creation for the province but will also raise the diversion rate and ultimately help achieve the province's position to ban organics being landfilled. A target of 50% diversion will be enforced in 5 years (2023) and a total landfill ban of organic waste in 10 years (2028) will take place.

Table 13: The following table indicates a takedown of the agricultural residue quantities in tons (GreenCape, 2017)

Agricultural Residue (tonnage)						
Western Cape	**CoCT**	**CW**	**Eden**	**WC**	**Overberg**	**CK**
2125100	46600	277700	392400	885100	507500	15800

Not all agricultural residues are landfilled. Large quantities do not leave farms and some wastes are also used onsite. Unfortunately, due to the lack of project management the quantities are not measured and thus the values for farms are not indicated.

During the data collection process, three main problems came to light in regard to the management of green waste in the agricultural sector. A lack of awareness of technologies; regulatory hurdles and a lack of waste management awareness and support to farmers are the three aforementioned challenges.

Some of the challenges raised were that farmers seemed unaware of other available technologies for the processing of green waste and that waste management support to farmers is a challenge for municipalities due to their remote locations.

Composting was identified as the most commonly used practice for green waste management for farmers, however few role-players who were contacted in general could mention other technology options for the processing of green waste (DEA&DP, 2017). The Green Waste Status Quo states that "Based on interviews with Municipal Waste Managers it

seems the common practice for the farmers are to use the green waste and produce their own compost". Furthermore, there was a clear lack of waste management awareness as many role-players could not see the need for new management techniques. This could be due to the lack of support and direction for role-players, but also the regulatory hurdles. The regulatory hurdles which need to be overcome by role-players can appear excessively daunting to an individual with no experience in the specific area.

6.2. Green Waste generating sectors in agriculture

6.2.1. Horticulture

6.2.1.1. Flower industry

Statistics from 2016 show that South Africa ranked 19th in the world for flower bouquet exports in 2016, effectively earning $36.1 million and providing 0.5% of the world total exports (Workman, 2017). As such, South Africa's formal flower industry should have a reasonably sized amount of green waste on a monthly basis. Additionally, with four fifths of the Cape Floral market containing fynbos, it is unsurprising that it has proven to be the preferred harvest product, providing for the livelihoods of farmers, poor households and communities in areas where unemployment is as high as 80% (Blokker, et al., 2015). Needless to say, the informal sector too needs to deal with at times large quantities of green waste from unsold flower waste, both fynbos and other.

Currently the informal flower market does not have a single answer to its flower waste. Waste flowers are either donated to hospitals, the less fortunate or other areas where they may be needed (if they are willing to fetch it); used for spiritual practices, or simply thrown out. Similarly, any cuttings produced while arranging the bunches are also thrown into the nearby municipal bins.

6.2.1.2. Nurseries

Nowadays nurseries generate large quantities of green waste but have effective systems of managing wastage and beneficiating their green waste. According to the Status Quo Analysis of Green Waste in The Western Cape, nurseries either use their green waste for compost or take it to the nearest drop-off facility.

6.2.1.3. Beneficiation options for Horticulture

There is a variety of options when it comes to beneficiation of flower waste. The practice also allows for job creation and automatically reduces waste to landfill.
Following is a table summarising beneficiation opportunities:

Table 6: Beneficiation techniques for waste flowers

Waste Flower Beneficiation	
Technology/Beneficiation	**Product**
Anaerobic Digestion (with food waste)	• Biogas
Extraction	• Dye • Feed • Incense from waste Flowers
Pyrolysis	• Biochar
Composting	• Compost • Worm tea (vermicomposting)
Cosmetics	• Liquid Hand Wash • Cosmetic creams
Dehydration of flowers & foliage technologies	• Fertilizer, Artistic greeting cards, wall plates, landscapes, three dimensional interior decorative items, potpourri, etc.

Case Study 1: Chickaballapur market

Students from Sir M Visvesvaraya Institute of Technology, Bangalore found that on average 750 tonnes of flowers were sold in the Chickballapur market on a monthly basis. The figures double during the festive season giving an estimate of 10000 tonnes per annum. Their studies showed that 5-10% of the flower waste was generated due to fluctuations in the demand or loss of

quality of flowers due to lack of preservation facilities. Unfortunately, the prevalent disposal practice is burning the waste or throwing it into water bodies.

To combat this, the students used Marigolds (which form a major portion of the flower waste) to create various cosmetic products. The students furthermore produced poultry/cattle feed as well as fertilizer from the flower waste, all of which proved to be safe to use (Rizwan, et al., 2014).

Case Study 2: Incense sticks from temple waste flowers

In Mumbai a 25-year-old started creating incense sticks from waste temple flowers. Nikhil Gampa, the creator of Green Wave, collects flower waste at temples, which are emptied every two days. The flowers are then segregated and set out to dry from where the dried flowers are powdered and mixed with binding powder and sawdust. Finally, this is rolled over with bamboo sticks to make the final product. Green Wave is not only producing about 15kg incense sticks per week, but the green business venture has created employment for women from low income communities as well (Halim, 2016).

Case Study 3: Kiat Lee Landscaping

Kiat Lee Landscaping and building is an international company which uses green waste from horticultural industries to produce compost of different grades which can be used both commercially and for end-consumers (Kiat Lee Landscape & Building, 2017). Similarly, nurseries can compost their green waste on site, thereby saving costs and potentially having another income. The biggest challenge in using this method is the possibility of contamination when creating the compost from the green waste on site.

Case Study 4: Power generation through flower waste (Kenya)

A pilot project in Kenya (on PJ Dave flower farm) has generated up to 80kWh of electricity from 1 tonne of flower waste. The plant is fitted with a 125kVA CAMDA gas engine generator as well as a reverse osmosis water filtration system for irrigation. On average flower farms generate 3-7 tonnes of flower waste per day which equates 240kWh – 560kWh per day. A project evaluation is still required but the savings were between US$ 18,650 to US$ 41,960 per annum.

Similarly, another Kenyan farm, Simbi Roses, has a biogas plant which relies solely on biodegradable flower waste as fuel source. The system purely uses shredded flower waste and has a digester capacity of 200m^3 and a gas chamber of 80m^3 capacity. The capacity of the biogas-fuelled generator is 55kW.

On average, out of the two tonnes of daily farm flower waste, 600kg of shredded cut flower leaves are fed into the hydrolysis tank. The shredded flower waste is mixed with water to dissolve the green matter which is then fed into the main digester. Mixing within the hydrolysis tank is done with the help of a 4kW motor. Insoluble part of the flower waste which remains in the hydrolysis tanks is taken out once every two months (Ogallo, 2015).

6.2.2. Orchards and Vineyards

Waste is generated in vineyards and orchards is mostly due to pruning. Trees are pruned seasonally but also need to be pruned when they are damaged, diseased or when they grow too vigorously (beyond management) (Vossen, n.d.). As such pruning fruit trees provide a seasonal source of green waste which can be sold as firewood. In addition, the leaves of certain trees can be used to obtain extracts, each of which have a variety of uses and benefits.

6.2.2.1. Beneficiation options for waste generated from orchards and vineyards

6.2.2.1.1. Extracts

An Extract can be defined as a preparation containing the active ingredient of a substance in concentrated form (Duerr, 2016). Leaves of many fruit trees can be used to obtain extracts which can be sold to gain additional income as well as reducing green waste. An example would be apple leaves that contain phloretin which is a natural antibiotic.

6.2.2.1.2. Wood

Wood from vineyards and orchards tend to be either used on site or sold overall. Fruit tree wood tends to burn clean and sought by some for indoor burning as well as cooking.

Case Study 5: Eco Logs

Recently, companies have been using the left-over product from grapeseed oil extraction to create eco logs. After grapes are used to make wine, skins and seeds are separated and dried. The skins are used as composting and grapeseed oil obtained from the seeds. From there the remaining waste from the grapeseed oil process is compressed and moulded into log shapes to be sold as "Eco Logs" (90by2030, 2012).

Figure 7: Examples of Eco Logs

- Eco fire & BBQ logs are produced from the normal harvest of wine each year and no additional vegetation is removed or damaged in the production process
- Eco Logs have a very high calorific/heat emission value and are therefore ideal for both BBQ and heating
- Heat emission is measured in mega joules per kilogram – mj/kg. The logs burn at 21.01mj/kg which rates as one of the highest when compared with non-eco-friendly alternatives.
- Eco Logs are environmentally friendly and burn really well in place of either wood or charcoal
- Eco logs are 100% recycled product and 100% natural (Eco Fire & BBQ Logs, 2016).

6.2.3. Cereal

Cereal waste can be used in the following ways:

- Building Materials for housing;
- Bedding and Feed;
- Mushroom Cultivation;
- Pulp Making;
- Cellulosic Ethanol Production; and

- Pyrolysis

6.2.3.1. Building materials for housing

Making bricks and walls from straw-clay mixtures is an ancient technique that is still used in house and shed construction in many poor countries, as is the use of cereal straws for roofing. Straw bale construction is an additional way of using agricultural residue as a building material. Moreover, there is also the approach to use clean shredded straw to make boards for interior partitioning via a heating and compression technique (Owens, n.d.).

Figure 8: Examples of straw bale housing

6.2.3.2. Feed and bedding

Feeding is the largest off-field use of cereal straw in poorer countries. A relatively large amount of residues is fed to ruminants even in rich countries, where other forms roughage (mainly grasses) are also readily available. Crop residues are fed to domestic animals in forms ranging from traditional stubble-grazing of harvested grain fields to preparations of chopped residues mixes that are made more palatable and nutritious by the addition of nitrogen-rich compounds (Smil, 1999).

Cereal straws are also a preferred material for animal bedding due to their excellent water absorption capacity. After use the soiled bedding can be composted and then used to improve soil quality (Smil, 2013).

6.2.3.3. Mushroom cultivation

Straw makes a good substrate because it is both nutritious and easy to break down. After the mushrooms have been harvested the bags can be watered and rested for a second harvest. This can be done until the bag stops producing mushrooms or mould sets in (Mushroom Appreciation, n.d.).

Figure 9: Oyster mushrooms growing out of hole from straw bag (Mushroom Appreciation, n.d.)

6.2.3.4. Pulp

Cereal wastes can be used to make pulp. There is a variety of advantages to using non-wood sources for pulp production. Easy pulping capability, excellent fibres for the special types of paper and high quality bleached pulp and that they can be used perpetually as an effective substitute where forest wood resources are being decreased (Akbari & Resalati, 2012).

6.2.3.5. Cellulosic Ethanol

Agricultural residue can be used to create Cellulosic ethanol. The process briefly follows the pattern of pre-treatment, enzyme production, enzymatic hydrolysis, fermentation, product purification and then cellulosic ethanol is obtained (Sunliquid, 2017). It has been highlighted as superior to corn ethanol due to its improved energy balance (more Btu's produced per Btu of fossil fuel used in the process), lower carbon emissions and less direct competition with food production (Hofstrand, 2009).

6.2.3.6. Biofuel

With the input of cereal straw biofuels can be obtained via the process of pyrolysis. Pyrolysis is explained as the breakdown of waste with heat and no addition of extra air or oxygen.

Case study 6: Straw burning in China

In the Henan Province in China a project was executed where farms were provided with small scale pyrolysis systems. This allows in-situ biochar and syngas productions from agricultural residue collected in the vicinity which can be used as gas for cooking and household use. The biochar can be returned to the fields to improve soil quality. There is also a mobile pyrolysis system which can be driven by a tractor to the cropland and convert biomass into only biochar for directly return to the fields. From about 400-500kg of wheat straw the machine can produce 120-150kg of biochar per hour. In Northeast China a few agronomists have innovated a small scale fixed pyrolysis kiln for farmer use in their field while they're harvesting maize. Both these innovations offer farmers an opportunity to burn the straw as biochar for burial in their soil instead of burning to air, which is not only detrimental to the environment but also to those who find themselves in the surrounding environment. The biochar amendment is also believed to improve the cadmium polluted rice fields for safer rice production in southern China rice areas where cadmium pollution is becoming increasingly extensive and excessive cadmium in rice is becoming a public concern (Pan, et al., 2011).

Figure 10: Example of mobile biochar kiln

7. Forestry

7.1. Overview of challenges in the sector

Forestry is divided into two sectors, indigenous and invasive alien forestry. Invasive alien forestry will be further discussed under alien clearing. Green waste generated in the forestry sector is commonly known as forestry residues. According to a study completed by the IWMSA (2014) these are small trees, branches, tops and un-merchantable wood that are typically generated

through operations such as the clearing and thinning of plantations, clearing and grubbing for construction, processing wood for pulp and timber products, and the natural and anthropogenic attrition of forests.

The indigenous forest is managed by South African National Parks (hereafter known as SanParks) and spreads mainly across the Eden District Region. According to SanParks 17 % of the forests, which are either dead or dying, are used for harvesting (du Plessis, L 2016, pers. comm., 20 October 2016). Green waste generated during this process is left in-situ to replenish the soil. This is also the common practice in plantations where green waste is minimal as the sector grows trees and processes lumber. This can however pose a fire risk.

On the other hand, waste generated from plantations consists of small branches and pine needles. These, as previously mentioned, are left on-site for mulch and stumps and roots are left in the ground. Common practice is that surrounding communities nearby collect these branches for firewood. Occasionally, the mulch left on-site is spread around or burnt to produce ash.

Sawmills produce lumber and other by-products which are sold for use in other industries. However, at sawmills, only around 50% can be used for roof trusses, furniture, agricultural poles, transmission poles, etc. The remainder (bark, chipped green waste, sawdust) is 'wastage'. Some uses are listed below:

- chipped wood are used in the Pulp industry;
- chipped wood and sawdust in the Hardboard and Medium Density Fibre Board (MDF) industry; and
- bark for use in the fertiliser and growing medium industry.

During a meeting on 20 July 2016, Braam du Preez of MTO Forestry Pty Ltd, indicated that almost 100% of bark is sold to nurseries as a growing medium. He also indicated that there is no market for Eucalyptus trees. Permission is therefore granted to woodcutters come and cut to allow them to harvest the trees for use as firewood. This provides them with an economic opportunity as well as a source of fuel (Pers. Comm.; du Preez 2016)

Waste generated at sawmills consist of shavings and off-cuts known as surplus mill residue. The surplus mill residue, i.e. green waste, can be used at pellet plants, composting industries, in steam boilers and used for power generation and wood brick production. However, common practice is to leave it in-situ. No forestry residue enters WDFs.

According to a study completed by the IWMSA (2014) an estimated 91 022 tonnes per annum of forestry residue is available for utilization. It is unclear whether this value accounts for both invasive and indigenous forests.

Table 7: Residue stats, 2014 Waste Source Quantities for Western Cape

Waste streams	Western Cape	City of Cape Town	Cape Winelands District	Eden District	West Coast District	Overberg District	Central Karoo District
Total (T)	7702280	3713700	1012500	938600	1185500	768000	83980
Forestry residues(T)	91 100	9100	4600	63 700	4600	9100	-
Percentage	1.18	2.45	0.45	6.79	0.39	1.18	0

Table 16: Residue stats, 2014 Waste Source Quantities for Western Cape

	SA	WC
Forestry residues (T)	211 679	91022

Green waste management methodology

Resource	Process	Primary product	Secondary product
Mature trees	Harvested for processing	Sawn timber (lumber Wood chips Fibre for paper pulp	Renewable energy from sawdust and off-cuts

Output product	Output product
• roof trusses • cable drums • pallets • structural timber	• chipboard • MDF (medium density fibreboard

	• Pulp (raw material for paper and packaging products)

7.2. Waste management options

The volume of wood waste created can often amount to as much as 50% of the true log volume processed in many sawmills. The management of housekeeping processes such as equipment and machinery layout should be organised in a way to minimise waste generation and drive down the handling costs of sawdust in order to realise optimum effectivity.

Solid wood waste often does not present disposal problems it always needed for fuel and is often purchased by local firewood contractors utilising their own transport and labour for loading. High density hardwood species make excellent charcoal and cut-offs are often used for this purpose either externally or internally.

The waste disposal goal must always be to produce as little as possible volumes of wood waste as possible. The daily production figures in respect of log volume sawn Vs sawn timber produced is a matter which sawmill management must always take into account.

Conversion for various species and hence the waste generated will differ relevant to the shape, size, inherent defects, quality and age of the logs in question.

Constant low conversion or wastage may be due to:

- Quality of logs involved
- Size and thickness of sawn timber commercially acceptable
- Operational efficiency of the sawmill staff
- Low standard of maintenance for saws and machines

7.2.1. Possible beneficiation of wood waste

The possible utilization of wood waste as a commercial product, which will create a financial return must therefore always be given very serious consideration. There are various possibilities which may be feasible and viable, but is dependent on the type and volume of the waste

material and the location of the sawmill. Some suggestions for possible outlets for sawdust, shavings, chippings and other small particles are as follows:

- consider the feasibility of a wood waste briquetting system whereby the materials are processed into high density fuel briquettes;
- look into the possible utilization of wood waste as a commercial mulch for use in agriculture or horticulture;
- investigate the likelihood of selling it as a litter for high density poultry or animal husbandry units;
- advertise the type and volume of material which is constantly produced for the attention and consideration of other wood waste processing industries or potential users;
- explore the possibility of getting local brick or tile-makers to use the sawdust as fuel for the kilns and also as a mix for producing porous bricks of reduced weight;
- contact local builders regarding the use of sawdust as a shield layer over concrete floors or roads to allow the concrete a change to obtain maximum, strength; or
- carry out a feasibility study on compacting sawdust into plastic bags to reduce the volume and subsequent transport costs which may attract a wider range of customers using small amounts.

7.2.1.1. Sludge

CASE STUDY 1: Key concept: Characterisation of pulp and paper mill sludge to establish the feasibility for beneficiation

Problem statement:

- pulp and paper manufacturing process generates significant quantities of non-hazardous solid waste
- requires management as either a waste or by-product
- waste/by-product consists of a sludge which contains fibres and or papermaking fillers in large quantities.

Current/conventional management process/techniques for mill sludge, a by-product of the pulp and paper industry

- Landfilled
- Incinerated
- Land spread

Activity

- Characterisation of pulp and paper mill sludge in order to identify and explore how to minimise the amount of waste being treated in the conventional way (landfilled, incinerated, land spread).
- Identify options for beneficiation – utilising the waste/by-product from the pulp and paper manufacturing process as a resource in another manufacturing process.
- Explore the options for waste minimisation (3Rs) in order to reduce emission of greenhouse gases into the atmosphere as well as reducing the occurrence of leaching of toxic substances into surrounding ground and water systems.

Rationale

Typically, pulp and paper mill sludge is traditionally landfilled, incinerated or land spread. Disposal in an economically and environmentally acceptable manner is of critical concern in modern industry. The environmental effects such as greenhouse emissions and leaching of toxic chemicals into surrounding ground and water sources. Pulp and paper mills typically generate significant quantities of non-hazardous solid waste which requires management as a waste material or as a by-product. Most of these solids are removed after primary mechanical treatment, resulting in a sludge that contains large quantities of fibres, papermaking fillers, or both. These materials can be utilised but needs to be characterised so that its exact composition and purpose/function/usability can be identified.

Present disposal methodology will not stand the test of time with the implementation of environmental policies and carbon taxes. These legal regimes bring about best practicable methods for the disposal of mill sludge as a result.

The characterisation of the sludge explores the components that make up the sludge in order to identify which products can be manufactured from it.

Project Status: Ongoing

Research findings

The results obtained showed that the sludge types differed depending on the mill processing techniques.

The research identified that the following products can be derived from sludge from the paper and pulp manufacturing process as a result of beneficiation:

- Biogas production;
- Nano crystalline cellulose; and

- Biopolymers, end products that can be manufactured

Various beneficiation applications for the products identified from the sludge characterisation process:

- Biogas as an alternative energy source
- Nano crystalline cellulose can be applied in the manufacturing of:
    - Adhesives
    - oil and gas
    - paper and non-wovens
    - cement
    - plastics and composites
    - paints and coatings
    - personal care items as a cosmetic ingredient
    - drug delivery products
    - organic growth platform compatible with bone and tissue
    - food and beverages (very stable emulsions which can improve texture and suspension quality of products
    - development of electronics with applications such as:
        - particle suspension ability
        - electro-magnetic response
        - conductivity through functionalization

(CSIR, 2018)

7.2.1.2. Energy generation

The feasibility of bioenergy production has been proven at a relatively small scale. The process involves mostly the processing of organic waste, residues from forestry and agriculture, and eradication of invasive alien plants. Power generation can be increased by improving efficiency in the utilisation of paper and pulp mill residues, sawmill residues (both forestry derived waste types) and sugar cane bagasse (Hugo; 2016).

The potential for using biomass as a feedstock for energy products is considerably reduced due to the reduced availability of arable land, rainfall and food security in South Africa. The best options for use as feedstock are urban organic waste and lignocellulose (which comprises

a mix of agricultural and forestry residue, and harvested invasive alien plants). The existing constraints do not eliminate the possibility of these types of projects (Hugo; 2016).

Legal requirements

White paper on the Renewable Energy Policy – supply and consumption of Energy; creates energy security by diversifying the energy supply and energy carriers.

Draft National Energy Bill

Government has set a target of 10 000 GWh renewable energy contribution to final energy consumption – to be mainly produced from biomass, wind, solar and small-scale hydro. The renewable energy is to be utilised for power generation and non-electric technologies such as solar water heating and bio-fuels. A phased an innovative approach is required if the renewable energy industry is to become a sustainable alternative to fossil fuels and attract investors.

Four strategic areas need addressing as identified in the White paper on Renewable Energy which includes: financial instruments, legal instruments, technology development, awareness raising, capacity building and education.

Energy related statutes include:

Electricity Act, 1987, Act No. 41 of 1987 – providing for the continued existence of the National Electricity Regulator and the control of the generation and supply of electricity and relate matters. This act ensures order in the generation and sufficient sypply of electricity.

The functions of the Regulator include the issuing of licenses, determination of process, settling disputes, collecting information and related matters.

National energy regulator act 40 of 2004 – although not applicable to renewable energy, but its provisions could be adapted in the Energy Bill.

National Environmental Management Act 107 of 1998 – the act governs sustainable development and aims to integrate social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations. It goes on to flesh out what is meant by the notion by stipulating a number of provisions the following being relevant to renewable energy.

National Water Act 36 of 1998

The NWA will apply for the generation of energy from hydro-electric power, which is not necessarily applicable in this case.

7.2.1.3. Beneficiation of wood waste from saw mills

Sawmill products suitable for biochar production

A study conducted by the Department of Environmental Affairs (DEA) to assess the potential of biochar to be used as a greenhouse gas mitigation option in South Africa indicated that during the processing of felled trees in sawmills, nearly 50% of the logs become waste wood material, with waste streams including sawdust, woodchip, bark, planer shavings and pole shavings (DEA, 2015). As such, the industry gives rise to large volumes of waste material that could be used to produce biochar or for energy recovery (Biomass Producer, 2013). A proportion of the residue biomass is often used for steam production in the sawmilling process; however, it is estimated that between 1,000,000 and 1,500,000 tonnes per annum still remains and is potentially available for the production of biochar (SSA, 2011). This estimation correlates with the data used in the Bioenergy Atlas produced by SAEON.

8. Alien Clearing

8.1. Overview of challenges in the sector

According to the Department of Water Affairs (2013), Invasive alien plants (IAPs) are a significant national problem, affecting almost 10 million hectares (8.28%) of the country, and spreading. Of the estimated 9000 plants introduced into South Africa, 198 are currently classified as being invasive (DWA, 2013). Their reasons for introduction are varied, and include their commercial value (crop species, timber and firewood), ornamental, stabilising sand dunes and as barrier and hedge plants. Others have been introduced accidentally. IAPs are seen as a threat in South Africa because they transform and replace indigenous vegetation and affect the functioning aquatic ecosystems by altering water quality and flow and unnaturally support an increase in some fauna (Kotze et al., 2010).

Amongst the above listed alien invasive plants found in the Western Cape, the highly distributed ones are pines, rooikrans, port Jackson, hakea, gum and black wattle. These alien invasive plants are shown in the graph below.

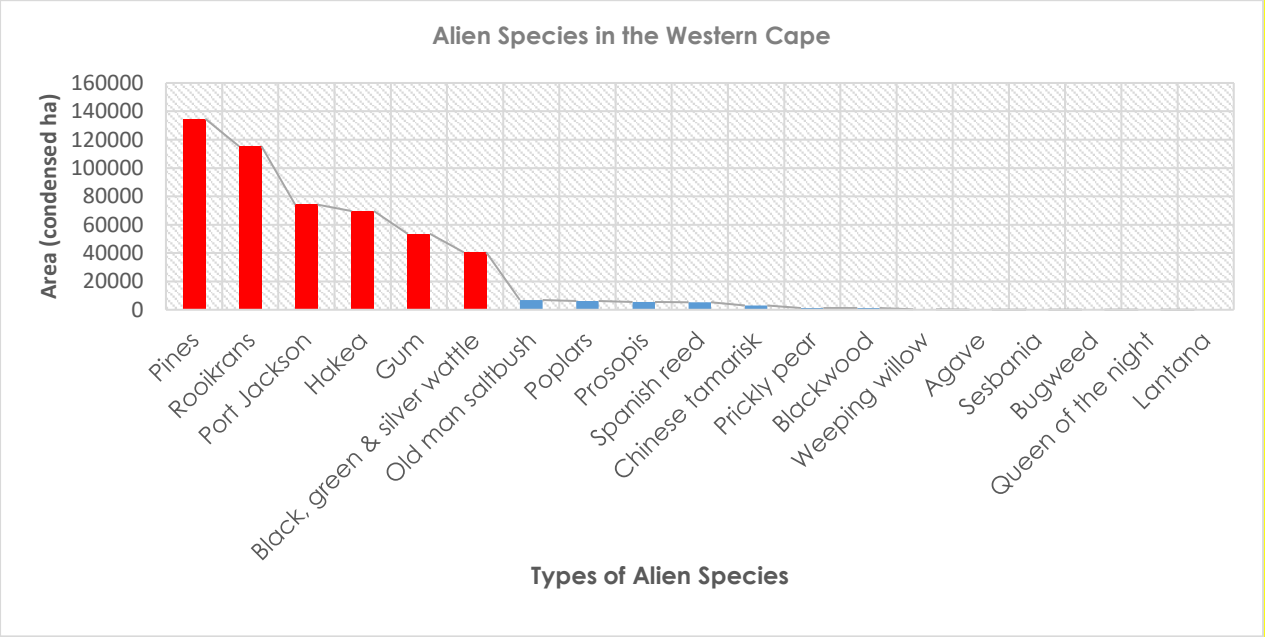


Figure 11: Alien invasive plants in the WC

Various stakeholders including Landowners are under a legal obligation to control invading IAPs and are looking for effective ways to use the waste generated from the clearing management of waste generated from the clearing. Furthermore, there are obligations that exist as a result of the various laws. The current relevant laws are listed below:

Table 8: Legislation related to the minimisation of IAPs

CARA (The Conservation of Agricultural Resource Act)	Lists all declared weeds and invader plants and provides removal requirements according to the plant's risk as an invader. This legislation is enforced by the Department of Agriculture and is currently in effect. This list categorises invasive plants as follows: **Category 1** – These plants must be removed and controlled by all land users. They may no longer be planted or propagated and all trade in these species is prohibited (e.g. long-leaved wattle, hakea, spider gum, inkberry, sesbania, pittosporum, oleander, stink bean, lantana, pampas grass, Spanish broom, Spanish reed, prickly pear, canna & several waterweeds). **Category 2** – These plants pose a threat to the environment but nevertheless have commercial value. These species are only allowed to occur in demarcated areas and a land user must obtain a water use license as these plants consume large quantities of

	water (e.g. rooikrans, Port Jackson, black wattle, blackwood, grey poplar, pine, several gum species, weeping willows, beefwood, sisal, castor oil plant). **Category 3** – These plants have the potential of becoming invasive but are considered to have ornamental value. Existing plants do not have to be removed but no new plantings may occur and the plants may not be sold (e.g. jacaranda (WC), syringa, manatoka, Brazilian pepper (WC), bottlebrush, cotoneaster, loquat, sword fern & morning glory).
NEMBA (the National Environmental Management Biodiversity Act)	Chapter 5 provides for the publication of Alien and Invasive Species Regulations. This draft regulation list categorises invasive plant species as follows: **Category 1a** – Invasive species requiring compulsory control. They have to be eradicated and no permits will be issued. **Category 1b** – Invasive species requiring compulsory control as part of an invasive species control programme. Due to their invasiveness, infestations may qualify to be placed under a government sponsored invasive species management programme. No permits will be issued. **Category 3** – These species will be regulated by activity. Individual plant permits will be required to import, possess, grow, breed, move, sell, buy or accept as a gift. No permits for riparian areas will be issued.

Alien Clearing Management Plans have been developed by specialist and in alignment with the applicable legislation to control the spreading of IAPs. During the clearing of IAPs, waste/biomass is generated from the clearing of invasive plants. The following section will focus on the treatment options of alien clearing waste.

8.2. Treatment options for waste generated from alien clearing

A number of potential options exists for the management of green waste in the Western (DEA&DP, 2016). The following table then provides a list of treatment options for waste generated from alien clearing.

Table 9: List of technologies for Organic waste

Technology	Type of alien clearing waste	Products/ outputs from recovery operations
Composting: • Open windrow composting • Controlled environment open composting • In-vessel composting	Grass, leaves, plants, cuttings, branches, tree trunks and stumps Untreated timber, Sawdust, shavings, timber offcuts, crates, pallets, wood packaging.	Mulches, composts, blended products, potentially woody material for pyrolysis, combustion or refuse derived fuel (RDF) manufacture.
Anaerobic fermentation	Potential alien woody organics	Potentially gas for renewable energy
Pyrolysis/ gasification	Alien vegetation dry wood organics	Renewable energy Syngas and synoil products for further refinement and use as fuel Biochar and other charcoal products
RDF Manufacture	Alien vegetation woody organics	RDF for us as fossil fuel replacement
Wood fuelled boiler	Alien vegetation wood	Wood logs (split or in pole form), chipped green waste or pellets used to heat a wood fired boiler.
Chipped Wood to supplement coal for boiler heat	Alien vegetation wood	Chipped Wood used directly to mix with coal in a coal fired industrial boiler.
Gasification to Heat	Alien vegetation wood	Logs, chipped green waste or pellets used in a gasification furnace to produce boiler heat.
Charcoal	Alien vegetation logs and branches	charcoal
Liquid Fuels	Alien vegetation biomass	Liquid fuel that can be used in as a transport fuel, boiler fuel or to generate electricity.

Source: DEA&DP 2016

The above table gives a summary of technologies that can be applied for the treatment of alien vegetation waste and into a valuable usable resource. The table further indicates the type of waste that can go into a specific technology and as well as the output. According to the Status Analysis of Green Waste in the Western Cape (2016), the market for green waste product is still growing as many of the potential value chains are still in their infancy. The next section further discusses potential value added products from alien vegetation biomass.

8.3. Potential value of cleared Invasive Alien Plants

According to a report conducted by TOMA_Now (2017), waste generated from the clearing of alien vegetation could potentially unlock significant beneficiation value chain that will increase job opportunities, prevent environmental degradation and as well as contribute to the county's economy. TOMA_Now in their report also indicate other benefits that arise from using alien vegetation biomass as a valuable resource and these are listed below:

8.3.1. Economic

According to TOMA_Now (2017), beneficiating biomass through alien vegetation from waterways can assist in offsetting clearing costs and generate jobs in typical farming and rural areas. Industry value chains can be created to support applications such as biochar manufacture, biomass to energy and composting. These applications from part of developing the green economy, booting local industries and communities.

8.3.2. Environmental

Beneficiating biomass through alien vegetation can also benefit the environment through the following means:

- Assist water management through removal of alien vegetation.
- Replace traditional applications with clean, renewable sources. Several applications have the potential added benefit of carbon sequestration to help offset the effects of global warming.

8.3.3. Social

Beneficiating alien vegetation biomass can also create jobs and skills development Potential investment into education, SMMEs, community health and infrastructure development.

According to TOMA_NOW (2017) finding a suitable use for the significant amount of biomass generated from the removal of IAPs has been a long-standing local challenge that also presents a unique opportunity. Optimising the value of biomass generated could help to cover the costs of clearing, potentially making it more economically viable and creating more jobs as stated above. The next section further illustrates various potential products that can be created from the cleared biomass and what they can be used for into the market economy.

8.4. Potential value added products from alien clearing waste

In 2015, the Green House Consultant conducted an economic feasibility assessment study for CASIDRA on the potential economic uses of cleared red gum from Berg and Breede River Catchment in the Western Cape and as part of the Working for Water Programme. This study concluded that red gum feedstock can be used as follows:

Table 10: List of useful uses of alien clearing waste

Value chain	Red gum (or other wood) sold as:	Indicative prices achieved	Comments
Firewood	Wet firewood delivered to existing firewood distributors	R400 to R 500 per tonne	The price paid includes delivery to the buyer/firewood distributor (except for farm pick-up price). Although recovery is high relative to sawmilling and poles, not all of the tree can be used for firewood so another use (such as composting or chipping) could be considered to complement firewood production for very small branches and leaves.
	Dry firewood delivered to existing firewood distributors	R 700 over tonne	
	Dry firewood sold to customers at farm gate	R 880 per tonne	

Value chain	Red gum (or other wood) sold as:	Indicative prices achieved	Comments
	Dry firewood delivered to customers	R 1,200 to R 1, 800 per tonne	
Wood chips	Wetter wood chips delivered to heating solutions company	R370 per tonne	This is the price that will be paid by Sustainable Heating, with the range depending on the moisture content. This includes delivery to the buyer. It is noted that Paarl Media is currently paying R 900 per tonne for chips, but this is considered to be financially unsustainable. As an indication for transporting the chips from Wellington to Cape Town would incur a transport cost to the order of R 100/tonne. The advantage here is that even the smallest branches can be chipped.
	Dry wood chips delivered to healthy solutions company	R 460 per tonne	
Pellets	Premium grade pellets (made from uncontaminated pine) sold to domestic customers	R 5,400 per tonne	This is the selling price of the pellets produced by Pellet Power for the domestic market sold in 15 kg bags, and is based on very high quality/purity pellets produced from pine shavings. (I.e. not necessarily relevant to red gum). Commercial grade pellets would sell for lower, but there is no substantial local market to get an indication of the prices for this grade of product.
Compost	Compost collected by distributor or customer from production site	R 175 to R 265 per tonne of wood feedstock to the composting process	This is the equivalent value of the wood before composting – in other words prior to accounting for the fact that there is up to 50% weight reduction during composting. This approach to representing these numbers was taken to allow for comparison to the other products.
	Compost sold to domestic customers through retail outlets	R 650 to R 875 per tonne of wood feedstock to the composting process	

Value chain	Red gum (or other wood) sold as:	Indicative prices achieved	Comments
Mulch	Mulch collected by distributor or customer at production site	R 450 per tonne	Higher prices can be achieved for mulch when sold through nurseries and other retail outlets. However, this will incur costs of bagging, transport and mark up of the retailer.
	Mulch sold to domestic customers through retail outlets	R 1,870 per tonne	
Sawmill planks	Logs (wet) delivered to existing sawmills	R 440 and R 880 per tonne	Only between 15% and 30% of red gum trees cleared from riparian zones is actually useable for plank production.
	Cut and dried red gum planks at factory gate	R 7,700 to R 10,250 per tonne	
Furniture			Varies widely depending on the product and part of the tree being used and hence no generalisations can be made. Prices paid for planks as inputs are as per sawmill planks in the previous line.
Poles	1.2 meter poles sold directly to customers	R 940 to R 1,020 per tonne	This is a figure as reported by one commercial pole supplier and varies depending on the diameter. Poles sold directly to farmers may achieve lower prices. Excludes delivery and VAT. It needs to be noted that this figure does not account for the fact that to the order of only 30% of the tree may end up as a pole – the remainder of the tree would have to be used for other purposes such as chipping.
Wood wool in wood cement composites			There is currently no one producing these products in South Africa, and as such it is impossible to obtain comparable prices for these products.
Wood fibre in MDF and Wood			Large manufacturers of these products were unable to provide an indication of what they would pay for wood delivered to their

Value chain	Red gum (or other wood) sold as:	Indicative prices achieved	Comments
plastic composites			factories. It is also not possible to obtain an indication of the relative value of the wood in these products based on their selling prices, given the complexity of the production processes.

Source: CASIDRA 2015

The above table illustrates different products that are made from red gum and that can also be made from other various alien vegetation biomasses. The table also gives market price suggested by existing industries within the alien clearing space and who are already selling/working within the alien clearing industry.

The status analysis report on the Management of green waste within the Western Cape highlighted the potential value added products from green waste including alien vegetation feedstock and these are highlighted below:

Table 20: More added Potential Value Added Products

	DESCRIPTION	INDUSTRY
TIMBER		
Saw timber (Logs, Sawed wet plants, Sawed dried planks)	Lumber sawn in-field or at a sa w mill to standard timber sizes. Primarily pine.	Timber wholesalers, Farmers
Laths and Poles	Laths are smaller diameter poles from 15mm – 50mm. Pole are classified in various classes from 50mm – 200mm. Poles can be naturally tapered or milled to an exact diameter. Primarily Pine and Eucalyptus.	Timber wholesalers, Farmers
Fire Wood	Fire wood are split logs usually 25-40cm in length for use as braai wood or in domestic fire places. All species.	Wholesale distributors, Retailers and Households; Fire wood harvesting and production at Agulhas National Park
MANUFACTURED PRODUCTS		

	DESCRIPTION	INDUSTRY
Eco-furniture	Wide variety of furniture manufactured using kiln dried timber from alien tree species. The school desks manufactured at the DEA Eco-furniture factories are good examples. Primarily Eucalyptus and Pine, but also Blackwood and other species.	DEA Eco-furniture factory, Private furniture manufacturers;
Eco-coffins	Coffins manufactured using timber from alien tree species. Primarily Pine.	Private manufacturers
Wooden toys	Children's toys manufactured using timber from alien tree species. Primarily Pine.	Private
Objects d'Art	Outdoor sculptures, solid benches, wooden ornaments	Private
Packing and fill materials	Wood wool shavings used to protect packaged products from damage during distribution. Used machine parts to soft fruit.	Private
CONSTRUCTION		
Material for low-cost housing	Untreated non-structural timber. DEA fire-proof wood-cement boards.	Private
Construction timber	Treated rough or planed planks sized to standardised dimensions of the construction industry. Manufactured laminated beams and shelving.	Private
Construction boards	Manufactured plywood and particle boards	Private

Source: *DEA&DP 2016*

8.5. The role of Natural Resource Management Programme

Since 1995, after country's transition to democracy, the South African government has developed a number of public programmes such as the Natural Resource Management Programme (NRM). The NRM programmes consist of four programmes namely Working for Water, Working for Fire, Working for Wetland and Working for Land. The main objective behind these public programmes is to sustain the functioning of natural ecosystems and their productive capacity, stimulate economic development and as well as alleviate poverty through the creation of jobs (DBSA, 2012). These NRM programmes are listed and described below:

8.5.1. Working for Water

In October 1995 the Department of Water Affairs & Forestry established the Working for Water programme (WFW), convinced of its economic efficiency and potential for job creation. The programme is currently facilitated by DEA and aims at clearing IAPs with mountain (water) catchments and riparian zones as the initial target. The programme was created to combat the rapid spread of IAPs that continues to put increasing pressure on the country's water resources (Giordano et al., 2012). The programme runs across all provinces in South Africa and below is a list of companies that are being funded by the WFW programme in the Western Cape.

Table 21: Selection of value added activities in the Western Cape being funded by Working for Water

Company	Location	Contact	Cell phone
Africa Forest Industries (Pty) Ltd	Genadendal	Mike	0827398633
Ecotech Forestry and Timber	Stellenbosch and Franschoek	Erik	0826038114
Woodpecker	Franschoek	Andrew	0218762228
Genadendal Timber Project	Genadendal	Johan	0827627260
DroomBoom Rustic Furniture	George/ Wilderness		

Source: DEA 2015

8.5.2. Working for Wetland

Working for Water was followed by the "Working for Wetland" programme in 2000. Its primary objective is the rehabilitation of wetlands that have been degraded or lost. At the same time, it focuses on maximising job creation, creating and supporting small businesses, while restoring the wetlands and the services that they support (Working for Wetlands 2005) (Giordano et al., 2012).

8.5.3. Working on Fire

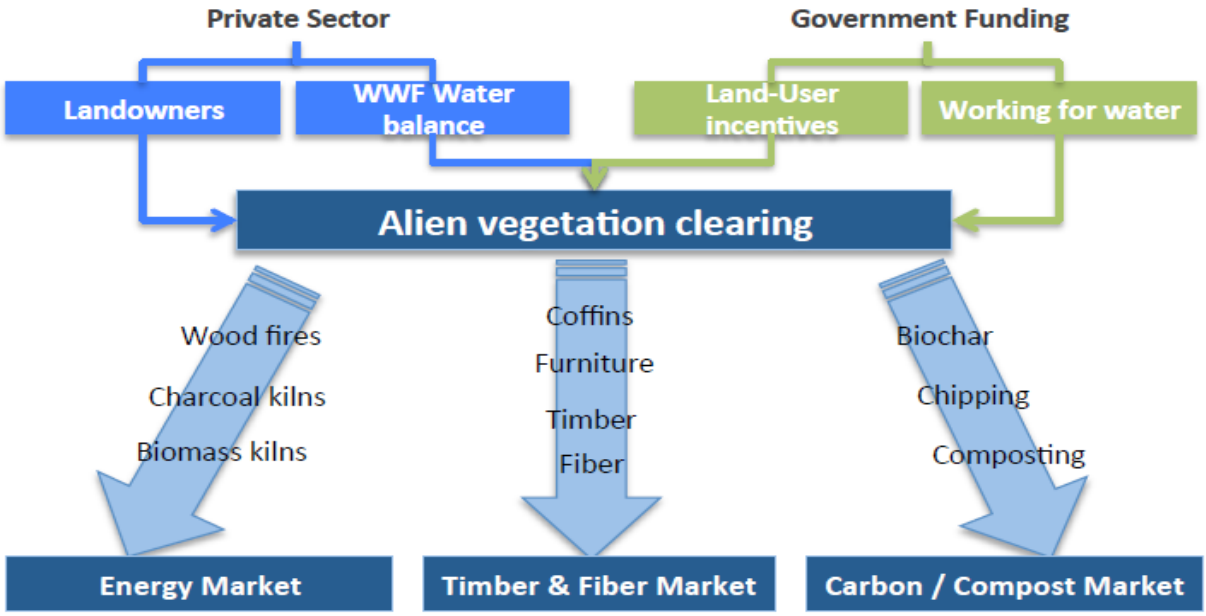
The next programme to be established was the "Working on Fire" programme, launched in 2003 to support land management agencies and private land owners with implementing integrated veld and forest fire management. Much of the country is dominated by fire-prone ecosystems that require occasional and well-managed fires to function properly. Furthermore, wild fires can cause much damage to property and infrastructure if not brought under control. The primary focus of this programme is therefore to stop wild fires from becoming catastrophic through an integrated approach to veld and forest fire management (DEA, 2005).

8.5.4. Working for Land

The latest addition is the "Working for Land" programme, launched in 2010, that aims to restore degraded land through the introduction of indigenous species (Giordano et al., 2012).

8.6. Value added chain

The removal of IAPs could potentially unlock significant quantities of water and is a critical pre-requisite for a water secure future for South Africa. But finding a suitable use for the significant amount of biomass generated from the removal of IAPs has been a long-standing local challenge that also presents a unique opportunity. Optimising the value of biomass generated could help to cover the costs of clearing, potentially making it more economically viable and creating more jobs.



Source: TOMA_Now 2017

Feedstock	Process	Products	Technology	Comments/ Process/ How technology works
IAPs	Pyrolysis	Biochar	Vuthisa	The technology considered is a mobile unit that generates biochar at the harvesting site. The biochar may then be buried at the site where it is generated or transported elsewhere for use.

IAPs	Pyrolysis	Biochar Electricity	Themex Carbontech	IAV is harvested and transported to a centralised pyrolysis unit where biomass is chipped, dried and converted to biochar and a gas stream, which is used for recovery of electricity. Electricity is generated via an Organic Rankine Cycle (ORC). This technology has less stringent feed requirements and comes at a lower capital investment than the gasification process of Prestige Thermal (value chain 3 and 6), but also has a lower overall efficiency. The process yields very high quality biochar or electricity production. This value chain was simulated for average values of all products produced and not optimised for specific product production.
IAPs	Gasification	Electricity	Prestige Thermal	The IAV is harvested and transported to a centralised gasification unit where the biomass is chipped, grinded, dried, gasified and the gas is then converted to electricity. No biochar or bio-oil is produced. Electricity is generated via a gas engine and heat recovered from the process is used to generate additional electricity via a steam turbine.

8.7. Case studies

8.7.1. Provincial

8.7.1.1. Waste to Energy: SENFORE Gasification Technologies

DEA&DP recently visited SENFORE, a company that created their own fast gasification and carbonization technology. A telephonic interview was also conducted with Luke Boshier and according to him, the technology is currently using alien biomass and sawmill residual but can run on any waste types such as

human waste to plastic and tyres, alien invasive vegetation, agro-waste in all forms, rubber, tires, plastics, medical waste, garden refuse and even solid sludge from sewerage works.

The technologies offer both normal Pyrolysis/carbon Cracking (Eco Creation manufactured) for selected waste streams of plastics, tires, rubber and bunker type oils, fast Gasification process for a broader range of waste streams such as municipal waste.

This new technology converts the feedstock material into carbon in the open- to- air, fast pyrolysis (such as the one shown above), continuous flow reactor, operating at temperatures of 600 – 900 °c (this varies with requirements). The process converts any organic, plastic or rubber material (raw input) from its existing structure/formulation/solid mass into Carbon (activated or non-activated).

8.7.2. National

8.7.2.1. Biomass to energy: Sappi

Sappi Southern Africa is set to build a 25 MegaWatt biomass power plant at its Ngodwana Mill in Mpumalanga. Sappi have invested in the expansion and modernisation of the plant, enabling higher production capacity in biomass fuel (TOMA_Now, 2017).

- Biomass is currently sourced in Sappi plantations.
- 344 jobs have been created during the 24-month construction phase and 120 direct jobs during operations and maintenance phase.
- 1.5% of revenue during the operational phase will be spent on socio-economic development, representing a long-term commitment in skills development, education, nutrition and social welfare.

8.7.2.2. Composting: Carbon reservoirs

Use of compost can reduce need for fertilizer, improve soil structure and reduce soil borne diseases.

- At least 30% of biomass waste in landfill can be used to create compost.

- A significant amount of carbon dioxide can be trapped, preventing release to the atmosphere.

- Composting has many uses as a soil conditioner and fertilizer. It can help with erosion control and stream reclamation.
- An application rate of 5 tonnes of biochar hectare can decrease fertilizer needs by 7% as a result of increase nutrient availability.

8.7.2.3. Heat energy: Biomass pellets

Wood pellets are a renewable and sustainable biomass fuel. They are generally small, highly dense and compact, unlike other biomass fuels such as wood chips. These characteristics make a stack of wood pellets easy to store and transport. There are power plants and heating plants in Europe running on green fuel shipped from South Africa. Biomass pellets can provide an ideal solution to the growing sustainable energy challenge. Direct thermal conversion of three million tons of wood pellets displaces the equivalent of almost 1,4 billion litres of fuel oil (TOMA_Now, 2017).

8.7.2.4. School desks from alien biomass

The project started 10 years ago, with a focus on invasive alien biomass to manufacture school desks for the Department of Basic Education. It has benefited 250 learners at Maatla Primary school in Maruleng, Limpopo by providing them with desks.

- The project is expected to create over 3000 jobs through the programme, across the country. Currently 226 full-time job opportunities have been created for previously unemployed people at the Ga-Rankuwa factory, mainly

from the city of Tshwane's Tshepo 10 000 programme.

The following table provides a list of stakeholders that can be contacted for the red gum potential use within the alien vegetation beneficiation.

Table 22: Stakeholders for further consideration

Name	Organisation	Contact Details	Comments
Sam Smout	WISP	021 811 0250 sam@green-cape.co.za http://www.greencape.co.za/	The Western Cape Industrial Symbiosis Programme
Grant Bramwell	Forest Creations	082 769 1345	Uses red gum to produce furniture, garden sleeps and decking.
Marc du Plessis	Universal Timbers	021 507 2628	Use red gum for furniture
Marc Casling	M&A Timbers	021 949 2600	Use red gums for furniture and exterior garden structures.
Loutjie Theron	Wood at heart	083 236 5473 loutjie@me.com	Uses red gum to produce furniture and wood wool composite boards.
Grant Trebble	SANParks	083 446 1447 gtrebble@iafrica.com	Manufacturers of school desks
Joy Crane	Furntech	082 330 0777 joyc@furntech.org.za	Training hub/business incubator
Justin Webber	Woodfellas	082 977 1199 Justin@woodfellas.co.za	Provide firewood for fireplaces and wood burning stoves
George Ferreira	TJ's Lekkabraai	021 905 1180	Manufactures charcoal and wood
Chris	Firewood Cape Town	082 448 6322	Produces firewood

Robert Koch	Donkerhoek	021 300 0237	Uses blue gum for firewood

Source: CASIDRA (2013)

9. Kelp/Seaweed

Kelps are large brown seaweeds that grow in underwater forests in shallow oceans. However, every now and again it washes up on beaches, especially after storms. Kelp plays a major role in keeping sand on beaches and preventing the erosion of dunes, and plays a part in the preservation of the integrity of coastal systems. It should be mentioned that very often the kelp that washes up on beaches are contaminated by human waste which makes it unacceptable for utilisation.

A common practice of coastal municipalities in the Western Cape is to collect kelp along shores with a digger loader. Due to the fact that the kelp is usually contaminated it is disposed of at the nearest waste disposal facility. The disposal of kelp is a concern as a major percentage of kelp is moisture which will contribute to the formation of leachate.

(http://www.desktopimages.org/preview/49803/1920/1200/o)

It is recommended that the municipalities attempt to remove any contamination contained within the kelp, and compost it as it has a high source of trance elements. It should however be noted that a kelp management plan must be developed by the Municipality. The provincial coastal committee agreed that a minimum amount of kelp must remain on beaches to ensure that natural processes are maintained. The minimum amount of kelp to be left on beaches should however be based on scientific information and guided by the Department of Agriculture, Forestry and Fisheries (DAFF) as the relevant authority for the administration of the Marine Living Resources Act (Act No 18 of 1998). However, if kelp is harvested a Marine Living Resources Act Permit will be required from the DAFF.

Internationally kelp is used as a plant-growth stimulant, and its extract is used within cosmetics and the following is extracted from the kelp: alginate, agar and carrageenan. It should however be noted that the technologies used to beneficiate kelp is usually expensive and complicated and subject to international market pressures.

10. Municipalities

10.1. Setting up and the management of drop-off facilities

Drop-off facilities provide an opportunity for businesses and the public to drop off volumes of recyclables including green waste free of charge or at minimum cost. The aim of these facilities assist with the reduction of illegal waste disposal and facilitate the recycling of various types of waste. The sites are normally located closer to communities and residents to accommodate those without transport. They are also often located at transfer stations that have material recovery facilities.[24]

Although drop-off facilities have been implemented by municipalities throughout the province the illegal dumping of green waste remains a challenge for municipalities.

[24] DEADP, 2015. Municipal Waste minimisation guideline.

One of the most important aspects of setting up a drop-off is its location in relation to the proximity of its citizens it intends to serve. To ensure as much green waste is diverted from landfill municipalities must ensure that drop-offs are placed in areas that are safe and user friendly. This makes it possible for all, both male and female, young and old, to make use of drop-offs without fear or stress when considering making use of a municipal drop-off facility.

10.2. Procuring the services of a contractor for the handling, chipping, and removal of green waste at facilities

To ensure the effective management of green waste at landfill facilities, drop-off facilities or transfer stations municipalities may use the services of a contractor. To acquire the services of a contractor the Municipality must present clear specifications when tendering for the services of such a contractor. The Specifications must clearly describe the service, the scope of work needed for the management of green waste, the supply and composition of green waste at various facilities, infrastructure, equipment and other resource requirements on site, provision of chippers and other important equipment for the effective and efficient processing of green waste, payment and invoicing methodologies, operating times, staffing needs, and various compliance needs with regards to the operational needs of the facility.

Furthermore, the tender specifications must clearly describe the requirements for day-to-day on-site operations, site and equipment maintenance, marketing of materials, and accreditation requirements.

An example of specifications of a tender provision for the handling, chipping, and removal of green waste service for the management of green waste at waste facilities can be viewed in **Annexure C**.

For more information on drop-offs please refer to the Department's Waste Minimisation Guideline, 2015.

10.3. Green Waste collection systems

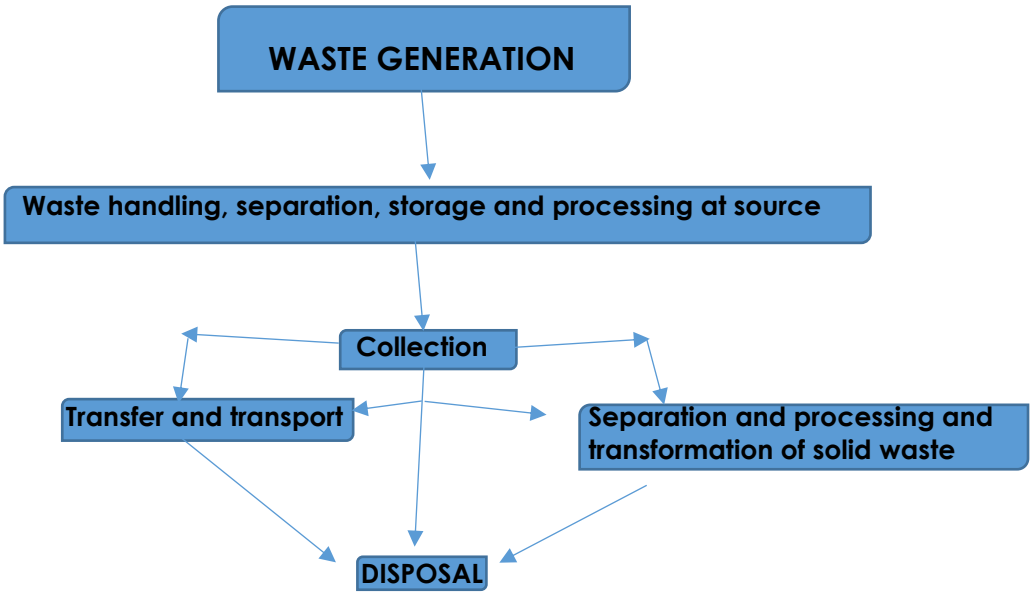
To consider collection systems specifically for the management of green waste, municipalities must evaluate the effectiveness of their existing system for the diversion of green waste from being landfilled. It is also important for municipalities to contemplate the seasonality of green waste, the sources of it and geographical spread of green waste potential with regards to current route services provided by the municipality.

Services are generally kerbside collection for households, large apartments and commercial and industrial businesses, communal self-delivery drop-offs, transfer stations, private waste collectors/garden service providers, a call-in service etc.

It should be considered to initiate a financial penalty system for residents and removers of Garden Waste if they do not separate the other waste from the Garden Waste.

A municipality's diversion programme must consider the following:

- Current drop-off system can be expanded to schools, existing facilities such as transfer stations, landfill sites (not for disposal), commercial facilities, etc.
- A new collection system in waste management must look beyond collection for disposal and include a collection service that focuses on the separation of recyclables such as green waste.



Changes to an existing collection system with the aim to include green waste collection must include:

- The amount of green waste generated in a service area;
- Current community relationship to existing and proposed services;
- Frequency of collection required;
- Point of collection (curbside, along alley ways, backyard or communal containers such as skips);
- System changes e.g. split bag system, new communal drop-offs etc.;
- Crew size required;
- Truck size or equipment type;
- Where green waste will be processing;
- Type of storage containers used; or
- Number of services.

ASSESSING CURRENT COLLECTION PRACTICES AND CONDITIONS[25]	
Determine Community Goals and Constraints.	
Fundamental Changes in the Required Collection Structure.	
Level of service.	• What level of service is required to meet the communities' needs? • What expectations exist with respect to the frequency of pickup and the convenience of set-out? • Communal collection requirements for recyclables such as green waste.

[25] How to Develop an Effective Solid Waste Collection Program: A Primer for Solid Waste Collection in Manado, North Sulawesi, Indonesia. Research Triangle Institute (USA) In association with PT Deserco Development Services, January 2004

Roles for the public and private sectors	• What role the municipality and the private sector can play in providing collection services for green waste? • How can the private sector participate in the programme? • Can the informal sector form part of this collection system or do they currently impede the collection of green waste.
Consideration for funding a new system	• How can improvements in the current collection system be funded?
CONSTRAINTS TO BE CONSIDERED	
Technical Constraints	• Is there sufficient technical expertise to design effective collection systems?
Financial and Economic Constraints	• Are sufficient funds available to finance the required improvements and systems?
Institutional Constraints	• Potential constraints by legislation that manages the procurement of municipal services. • Are legislative mandates for the management of green waste implemented and or enforced?
IMPLEMENTING AN EFFECTIVE COLLECTION SYSTEM	

- **A change in a solid waste collection system affects 3 groups of people:**
  1) **those responsible for the solid waste collection and transfer program**
  2) **the solid waste collection crews, and**
  3) **the waste generators.**
- **An information education and awareness program must inform those affected by the changes to ensure cooperation in accomplishing the desired change and in the performance of the collection process.**

10.4. CAPEX and OPEX requirements

Table 11: Capital and operational budgetary considerations for infrastructure and technologies

BUDGETARY REQUIREMENTS	INFRASTRUCTURE/TECHNOLOGIES	CONSIDERATIONS	RATING: LOW, MEDIUM, HIGH
CAPEX **Once off investment expenditure for the acquisition or upgrade of immovable, physical, non-consumable assets/infrastructure, such as a building or technology**	• Composting equipment such as chippers. This depends on the size of the operation. • More high-tech equipment could be considered	• Upkeep and maintenance will be running cost and must be considered under operational expenses. • Skilled staff requirements for the operation of equipment	Low to Medium CAPEX approx. R4 to R5 million
	• Construct a Facility such as a drop off	• During the planning phase low maintenance requirements must be considered.	Medium/ High CAPEX
	• Renovation/extensions to existing buildings/facilities	• To consider the use of used building materials such as fencing form	Low to high CAPEX

		construction and demolition waste	
	• The acquisition of waste to energy technologies such as a waste to energy plant o Biochar o Gasification o Pyrolysis o Torrefaction o Air curtain	• Once bought or installed the operational upkeep and maintenance will be your running cost and thus be under operational expenses.	Medium/High CAPEX
	The acquisition of an Anaerobic Digester	• To ensure the availability of the required feedstock for all technologies	Medium/high CAPEX
OPEX **Operational expenses are ongoing expense that a municipality spend on the day-to-day operations of a municipality's functions and service delivery needs.**	• Staff requirements	• Skilled personnel for the operating of technology plant • General staff for the day to day running of the facility • Safety of staff (availability of PPE's)	Low to medium OPEX
	• Training needs	• Ensure training needs are met and budgeted for	
	• Day to day equipment needs and its maintenance and the cleanliness of the facility	• A monthly fee charged to the Contractor for Water and electricity	Medium OPEX
	• Operational upkeep and maintenance of waste to	• To alleviate operational expenditure, the	High OPEX

	energy technologies such as a waste to energy plant	Municipality can build it into a Tender and place most of the Cost for OPEX on the contractor	

10.5. Municipal benefits of diverting green waste from the domestic waste stream

By diverting green waste from the domestic waste stream can have tremendous benefits for municipalities. Green waste diversion also helps:

- It reduces greenhouse gas generation and municipalities may access carbon credits should they beneficiate it for composting or other waste to energy application.
- To reduces pollution and landfill airspace.
- To create jobs. The involvement of people in the value chain creates additional job opportunities.
- Green waste serves as a fertilizer and soil amendment after undergoing decomposition processes at composting facilities or through anaerobic digestion.
- Landfills might be able to use it as alternative daily cover to reduce the usage of virgin soil cover materials.
- Green waste can be processed into wood chips and green waste mulch, it can be used for landscaping, dust control, erosion prevention, and weed suppression.
- Chipped green waste can be sold to generate an income stream for the municipality

Some of the negative impacts of poorly managed green waste include:

- High volumes of green waste occupy scarce landfill airspace;
- Requires expensive landfill containment barriers (liners) to mitigate; and
- Contribute towards greenhouse gases from the production of methane gas during decomposition.

10.6. Public awareness initiatives.

These awareness initiatives can be implemented across all the different community groups:

- Exhibitions or displays: as an outreach activity
- Road shows: travelling outreach and information sharing Workshops
- One-on-one education for more focused information sharing
- Stage plays/drama to raise community issues that can be discussed at a later stage
- Media for publicising critical issues like collection days and changes in the system
- Walkabouts to assess the impact of the service as well as identify areas that need extra attention regarding operation and education
- Clean-up campaigns to educate and involve people
- Competitions
- Surveys

Awareness raising materials could be used in conjunction with awareness-raising activities to enhance important messages:

- Posters
- Pamphlets
- Banners
- Videos
- Worksheets

The City of Cape Town currently has an internal competition and award system where the Drop-off Facilities are evaluated on ambience, waste separation, recycling and Waste Management. This helps to motivate the people running these facilities to do their best. The City of Cape Town also holds home composting workshops. Awareness of initiatives within the Municipality and Town must be communicated to the residence.

10.7. Setting up of PPP for the management of green waste

LEGISLATION	RELEVANT SECTION OF REGULATION
Public Finance Management Act, 1999 (Act No. 1 of 1999) (as amended by Act No. 29 of 1999) (PFMA)	National Treasury Regulation 16 (Republic of South Africa March 2005) Section 33, Chapter 11, Section 113, Section 114(1)

The Municipal Systems Act, 2000 (Act No. 32, 2000) (MSA)	21A, section 76(b)(iii), Section 77, Section 78
Municipal Finance Management Act, 2003 (No. 56, 2003)	Section 120, Section 33. (1)
MSA must be read with the Local Government Laws Amendment Act 2000 (Act 51 of 2002) and the MSA Amendment Act 2003 (Act 44 of 2003).	

South African law defines a PPP as a contract between a public sector institution/municipality and a private party, in which the private party assumes substantial financial, technical and operational risk in the design, financing, building and operation of a project and / or the performance of the function and/or use or management of municipal property. A private party, according to the Treasury Regulations, discounts public institutions such as a municipality, a municipal entity or an organ of state, including an institution listed in any of the Schedules to the PFMA or in section 76(b) (iii) of the MSA. A "Public-private partnership" is therefore viewed as a viable business contract between a municipality and a private party.

For more information, see **Annexure B**.

10.8. Funding your green waste management facility

For municipalities to develop capacity for the efficient and effective management of green waste, municipalities should consider accessing funding opportunities for the design and commissioning of new waste management facilities, including communal collection points, drop off sites, waste transfer stations, infrastructure, machinery, equipment, and operational and maintenance costs. Funds generally targets a diverse range of enterprising ideas for providers offering alternative renewable energy, clean and environment friendly energy or energy and emissions savings products and service providers, recyclers, waste managers and green building service and product providers.[26]

[26] http://www.smesouthafrica.co.za/16108/R300-million-green-fund-launched/

There are a variety of different capital and operational funding sources for waste management in South Africa. To complement existing budgets or lack thereof municipalities should consider internal and external funding sources such as:

National to local fiscal transfer mechanisms, such as:

- MIG grants
- The Green Fund
- The Jobs Fund
- EPWP programmes
- Development Bank and international development organisations

Sources of Funding can be done via Social Responsibility, Policy and Projects (SRPP), Expanded Public Works Programme (EPWP) and Government Outcome Based Approach Grants.

A municipality can apply to Department of Environmental Affairs to access this fund. Contact Details: The SRPP helpdesk: Tel: (012) 310 3426 or E-mail: srpphelp@environment.gov.za[27].

For a list of possible other grant options provided by development finance institutions and other non-government grants refer to Annexure 3 of DEA&DP's Waste Minimisation Guideline for Municipalities, 2015.

11. Conclusion

The effective management of green waste can hold tremendous benefits for municipalities and the private sector. Case studies show that if treated as a resource and beneficiated with quality in mind, it can be a good income stream with the potential for job creation, while also extending landfill airspace, reducing greenhouse gas emissions and meeting national and provincial waste diversion targets.

However, to unlock the true potential of this resource requires knowledge sharing, systems for the mandatory reporting and recording of green waste data, public private partnerships and often a regional approach in managing it.

In many instances the management options require comingling green waste with other organic waste types and hence it is imperative that all stakeholders in the organic sector meet as a collective when finding solutions. While the guideline provides current available options for the better management of green waste and is a good decision making tool, opportunities

[27] D: EADP 2015. Waste Minimisation Guideline for Municipalities

for knowledge sharing and engagement with stakeholders in the organic sector must not be discounted to ensure that appropriate solutions are found. Some important stakeholder engagements to consider are:

- Regional forums inclusive of all organic waste generators and treaters with government agencies.
- WISP linkage to allow for sharing of waste and resources in a geographically defined space.
- Improved dialogue between the industry and the national departments to address existing challenges.

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Annexures A – Composting

Composting Recipe

The best compost recipe ensures the speedy breakdown of the organic fraction and keep the impacts such as odour, leachate generation and the attraction of vermin and pests to a minimum.

Composting operations that are well managed and make use of a good composting recipe, significantly more material can be processed to produce quality products. Poorly managed sites with a poor composting recipe generally produce poor quality products.

Also, by shortening the storage time of feedstocks such as the green waste and other organic matter used in composting, will improve the processing capacity of the site.

The devising of good compost recipes is vital for a composting operation to maximise revenue generated from the sale of products in the market place. Key aspects that affects a composting recipe are:

- C:N ratio (Carbon: Nitrogen)
- moisture content;
- particle size and porosity
- pH; and
- other nutrients such as phosphorus.

Most organic by-products can be used as good quality feedstocks such as poultry, hog and cattle manures, food processing wastes, sewage sludge, municipal leaves, brush and grass clippings, sawdust, and other by-products of wood processing. Optimal conditions for fast, aerobic composting can be viewed in Table 24.

Table 12: Optimal conditions for rapid, aerobic composting[28]

Condition	Acceptable	Ideal
C:N ratios of combined feedstocks	20:1 to 40:1	25-35:1
Moisture content	40-85%	45-60% by weight
Available oxygen concentration	>5%	>10% and more
Feedstock particle size	<2,54cm	Variable

[28] Page 3 of The Art and Science of Composting: A resource for farmers and compost producers. Lesley Cooperband. Center for Integrated Agricultural Systems. March 2002.

Bulk density	593.276421 kg / m^3	593.276421 kg / m^3
PH	5.5-9.0 6.5-8.0	5.5-9.0 6.5-8.0
Temperature	43-66° C	54-60° C

Where possible a variety of feedstocks should be used together to produce the "ideal" range of conditions. This is not always possible but composting is a process that can take place over a wide range of conditions particularly if materials are mixed with a focus on acceptable moisture content and carbon-to-nitrogen ratio that goes hand in hand with good management practices the product will be an acceptable one. General, the combination of feedstock quality and compost management will determine the quality of the finished product.[29]

When is the compost process complete?

The final product of compost can take anything between 3 months to 2 years. The time needed for compost to mature rest on things like the feedstocks, composting method used and management. The compost process is considered complete once the raw feedstocks are no longer actively decaying and are biologically and chemically stable.

When reference is made to compost as stable it refers to the state of biological activity. Maturity frequently refers to the degree of humification which is the conversion of organic compounds to humic substances, which are most resistant to microbial breakdown. Compost stability is easier to measure than maturity, therefore composters generally measure compost respiratory (oxygen consumption) and temperature.

Once the centre of the pile's temperature 'returns to near-ambient levels and the oxygen concentrations in the middle of the pile remain greater than 10-15% for several days, compost is considered stable or finished'. Once the compost pile has a 50% moisture content by weight then these measurements should be taken.

It is important that compost site managers understand the importance of and know how to assess the maturity or stability of the compost. Compost stability will affect many of the

[29] The Art and Science of Composting: A resource for farmers and compost producers. Lesley Cooperband. Center for Integrated Agricultural Systems. March 2002.

chemical and biological properties of the compost, and ultimately how the compost can be used.

Biologically unstable or immature composts should ONLY be used on farms as a soil amendment. It can be applied several months prior to planting. Immature composts can also be used in site remediation, and as land fill covers.

Home Composting

Home Composting[30] is considered the best solution for the management of household garden waste such as grass clippings and leaves which can be used alongside the composting of fruit and vegetable waste. Composting at home circumvent the monetary and environmental cost of transporting waste to a processing facility. Another great advantage is that your garden will benefit from the free, organic compost that will be generated.

Upfront information on the composting process will help households to understand how to compost that can produce a high quality, usable product. The following information[31] municipalities need to share with residents to make sure residents follow the correct procedures for home composting projects:

- What is composting?
- Good reasons why you should compost
- How to compost?
- What goes into compost?
- What can you use to make compost? (Do and Don't)
- Method of composting
- Compost maintenance
- Key elements of good decomposition
- Problems and solutions
- FAQ

In 2012 the CoCT embarked on a Home Composting Pre-Feasibility Study that was identified as a priority through the City's Municipal Systems Act Section 78.3 process done in 2012 to access alternative service delivery options for its Solid Waste Management Services.

[30] http://www.testvalley.gov.uk/wasteandrecycling/gardenwaste/garden-waste-collection-service-frequently
[31]The CoCT Solid Waste Home Composting Research Project: Compost Training Manual. 2012

The MSA S78.3 Report highlighted the estimated tons per annum of household garden waste and kitchen waste that was being landfilled and therefore recommended a home composting research project to help further investigate options other than disposal at landfill for these waste streams.[32]

The project, its outcome and feasibility can be very useful for municipalities who wants to consider home composting as an option for the diversion of household green waste from being landfilled. Municipalities are encouraged to make reference to the CoCT's Report on their home composting research project when considering home composting in their areas.

What is the best food for your decomposers?

Remember while any organic materials can be composted, not all should be added to a home composting bin or pile. Table 25 highlights the organics that may be used in a compost pile and materials that should be avoided.

Table 13: What organics to put in your home compost bin or pile

Organic wastes that should be composted	**Things that are good to compost in your Home compost pile**
Leaves	Garden trimmings
Garden trimmings	Grass clippings
Grass clippings	Kitchen scraps
	Leaves
	Potting soil
	Manure
	Sawdust
	Hair
	Straw
Materials to avoid	
Oil, fat, grease, meat, fish or dairy products, unwashed egg shells as they tend to attract pests, vermin. Weeds, including weeds that have gone to seed (could infest garden area when compost is used). Home compost piles does not generate temperatures high enough and for long enough periods of time to kill weeds and their seeds.	

[32] Report on the City of Cape Solid Waste Management Home Composting Research Study: Phase 1 – Pre-feasibility study. Solid Waste Management Department, Waste Minimisation Unit. Final Version: January 2013

Although it is popular believe that one should add lime to a compost pile the mature product, compost, is always close to neutral in pH even if acidic materials were added to the pile. Remember, high pH compost is not desirable for most home gardens and adding lime to the pile will often create ammonia odour. Wood ash will improve the potash (an alkaline potassium compound, especially potassium carbonate of hydroxide)[33] of the pile which is a good thing. But large amounts of wood ash will tend to increase the salt content of the finished compost so use it sparingly.

Home composting technologies

Home composting technologies include:

- Enclosed bins;
- Rolling bins;
- Compost piles;
- Mini kitchen compost bins and
- Compost tumblers.

Compost Pile Management idea

A tracker (front-end loader) can be used to turn a pile. A specialised windrow turner can also be used. They both have pro's and con's. The advantage of how to use a front-end loader is that most farmers have access to one and know how to use one. They are fairly efficient at turning the compost. A specialised compost turner is far more efficient than a front-end loader which takes much longer. Specialised compost turners are quick and highly efficient but they are expensive and requires a tractor with sufficient horsepower and other equipment.[34]

Monitoring[35]

There are four primary pile conditions to assess when employing monitoring practices:

MONITORING

PILE TEMPERATURE MONITORING

PILE MOISTURE CONTENT MONITORING

PILE STRUCTURE MONITORING

PILE ODOUR MONITORING

The importance of monitoring the pile with a compost thermometer is that it gives you information that will help you make decisions on when to turn a pile. When temperatures fall below 45˚C in the first two to three weeks the pile turning the pile will replenish the oxygen and expose new material to microbial decomposition. When temperatures reach 65˚C the pile must be turned to prevent over-heating, and to maintain an efficient composting process.

Additionally, correct turning of the pile will assure that the compost throughout the pile is exposed to high temperatures in the centre of the pile to kill pathogens and weed seeds making sure the final product is homogenous.

Although monitoring informs composting site managers on decisions such as when to turn and when to water, it also provides an insight into how the compost is progressing and when it has reached completion, as indicated by temperatures approaching ambient.[36]

Composting treatment options

There is a number of treatment options for the composting of green waste. These options could have a high level of manual input or may require a high level of mechanical input or a combination of both. The commonly used composting options are vermicomposting, compost drums, bins or barrels, open Windrows, turned or agitated bays or beds, and in-vessel units.[37]

The Composting process can yield a variety of products such as mulch, soil amendments, organic fertilisers and blended products. A description of the different products and uses are described below in Table 26.

Table 14: Description of the different products and uses [38]

Product	Description	Uses
Mulch	**Fine mulch:** Between 20% and 70% by weight of particles having dimensions of less than 16mm.	**Fine mulch:** Can be used on any land surface Is for moisture conservation, weed control and

[36] http://agriculture.vic.gov.au/agriculture/farm-management/recycling-and-waste-management/composting-spoiled-hay
[37] The National Organic Waste Composting Strategy: Draft Guideline document for composting. February 2013
[38] The National Organic Waste Composting Strategy: Draft Guideline document for composting. February 2013

	Coarse mulch More than 70% by weight of particle size exceeding 16mm. **Pasteurised mulches** are either fine or coarse mulches that have undergone 'hot' composting to kill weed seeds and pathogens but are still too biologically active for safe use in sensitive applications. **Composted mulches** are either fine or coarse mulches that have undergone a controlled composting to meet stabilisation requirements.	soil conditioning benefits. The above applications are commonly used in urban landscaping. **Course mulch:** These mulches are typically used for moisture conservation and weed control in viticulture, erosion management and landscaping. **Pasteurised mulches**: Pasteurised mulches are still very biologically active and can have nitrogen and other nutrient draw down, pH, self-heating and phytotoxicological impacts on plants in sensitive uses. **Composted mulches:** for use in sensitive uses.
Soil Amendment	A range of soil amendments may be made from recovered organics, including composted soil conditioners, and liquid and organic fertilisers. Soil amendments may be sold in bulk (wholesale market) or be packaged for retail markets. **Composted soil conditioners** have less than 20% by weight of	These products can be applied and integrated to land to provide biological, chemical and physical benefits to soils. They can also be blended to produce topsoil, growing media or specific soil treatments, for example, compost with added gypsum is marketed as a 'clay breaker'.

	particles exceeding 16mm, and meet stability requirements.	Matured composts, particularly those deliberately manufactured to do so, can provide plant disease suppression benefits as composts or liquid compost extracts or 'teas'.
Organic Fertiliser	**Liquid fertilisers** can be made from composts, liquor from Anaerobic Digester (AD) processes or ammonia gases extracted from emissions from AD processing. **Organic fertilisers** can be produced from AD sludge or compost products manipulated or blended to have higher N:P:K benefits than conventional composts.	
Blended Product	Composted products may be graded and blended with other materials to produce a range of products. Common examples are topsoil and growing media. Where soils are sourced from urban sources or current or former farmland, soil testing protocols should be in place to ensure that	

	contaminated soils are not used in products. Additives such as fertilisers, coal dust, gypsum, wetting agents and water holding substances may be added to products to improve performance and appearance. The provenance of all additives should be recorded in batch records within a quality management system, to allow any issues with processes or product quality to be traced back to source.	

Vermicomposting

The composting process consist of two phases referred to as the thermophilic stage and a maturing stage. During the thermophilic stage is where the decomposition of feedstock happens very intensively and is considered as the active phase of composting. In the maturing stage there is a reduction in temperature to the mesophilic range and residual organic compounds are degraded at a slower rate. Vermicompost or vermicast is produced using a variety of worm species, such as red wigglers, white worms, and other earthworms, to decompose vegetable or food waste, and green waste.[39]

[39] https://en.wikipedia.org/wiki/Vermicompost

Earthworms act as mechanical blenders and by reducing the organic matter to smaller portions they modify its chemical and physical status as it steadily reduce the C:N ratio and exposes microorganisms to a larger surface area. These conditions created by the earthworm creates a favourable environment for microbial activity and further decomposition.[40]

Worm farming is perfect for the home. At home you can put all your organic kitchen scraps, soft garden waste (not twigs), soiled papers and even cardboard into your worm farm. They will even break down dog and other pet faeces but only in small quantities.[41]

Some of the benefits of Vermiculture:

- Earthworms need very little care
- Compost remains odour-free
- Vermicompost and Vermi-tea are generated
- Rise in plant health and growth including improvement in the fruit and flower yields

Large scale worm farming

[40] http://jdguez.webs.uvigo.es/wp-content/uploads/2012/01/Relationships-between-Composting-and-Vermicomposting.pdf [Chapter 2 Relationships between Composting and Vermiculture, Jorge Dominguez and Clive A. Edwards. By Taylor & Francis Group, LLC 2011]

[41] http://www.capecontours.co.za/2016/06/08/need-know-vermiculture-worm-farming/

Local earthworm companies	
http://ecowormfarms.co.za/	Phone: 021 715 0191 esther@ecowormfarms.co.za
http://www.fullcycle.co.za/index.php/vmchk.html	Phone: 021 789 2922 Email: mail@fullcycle.co.za
http://globalworming.co.za/	Phone: 084 210 6234 info@globalworming.co.za
http://www.worm-farm.co.za/	Phone: Alan 082 851 9585 Phone: Paul 082 906 4909 email:paulM@worm-farm.co.za
http://www.wizzardworms.co.za/	Phone: +27 33 413 183 Phone: +27 76 875 thewiz@wizzardworms.co.za don@wizzardworms.co.za

Open Windrows/Piles (Aerated or other)

Continuous Aerated Windrow Composting[42]	
• **8 m wide x 3 m high windrows** • **Forced aeration** • **Turned 2 -3 times per week** • **Raw material in one end, compost comes out the other end**	
Four main Composting Technologies	
Turned windrow composting	• Makes high quality compost because of the turning and size reduction • Most suited to outdoor processing • Batch process, doesn't account for shrinkage during composting
Aerated static pile composting	• Speeds up the composting process through forced aeration • Can accommodate large piles or windrows, covered or uncovered • Needs good porosity to prevent preferential air pathways • Batch process, doesn't account for shrinkage during composting
Agitated channel composting	• Turning and aeration produces high quality compost • The continuous flow design combines material flow with the composting process • Higher capital cost because of the concrete walls and specialized turning equipment on the walls
Mass bed composting	• The continuous flow design combines material flow with the composting process • Can be combined with aeration to produce high quality product in a shorter time period Requires a very wide building if under a roof
Turning **is important for speeding up the composting process because it breaks preferential air pathways, and brings the material from the outside to the centre for pathogen kill.**	

In-vessel units

In-vessel composting is a group of methods that confine the composting materials within a building, container, or vessel.[43] In-vessel composting systems can vary from metal or plastic

[42] Continuous Aerated Windrow Composting: TRANSFORM Compost Systems, John Paul, Ph.D. USCC Conference 2011

[43] https://en.wikipedia.org/wiki/In-vessel_composting

tanks or concrete bunkers in which air flow and temperature can be controlled, using the principles of a "bioreactor". Depending on the system used air circulation is metered through hidden tubes to ensure fresh air is injected under pressure and the exhaust is extracted via a biofilter. Temperature and moisture content is monitored using probes in the body of the material to ensure optimum aerobic decomposition conditions.

Annexures B – Public-Private Partnership

Public Private Partnerships (PPP)	
Why is PPPs important in waste management?	Municipalities, who are mandated to deliver essential services such as waste management, find it challenging to deliver an integrated waste management service that includes waste minimisation, improved management of landfill facilities, and the development of new waste management systems that require large infrastructure, opposed to merely collect and dispose.
Driving factors of value for money	
Risk Transfer	• Output based specification • Long-term nature of contracts (including full life cycle costing) • Performance measurement and incentives • Private sector management skills • Competition • Other value for money drivers have shown to be: o Innovation o Alignment of interest of authority and contractor o Public sector comparator o Public sector project development skills

	○ Quality of advice to public sector and bidders ○ Transparency of process ○ Cost to capital ○ Deal flow ○ Public sector implementation ○ Release of hidden asset value ○ Involvement of third party financiers
Cost Efficiencies	PPPs encourages increased competition that leads to cost efficiencies, such as value for money, an improved proportion of risk, a closer examination of the different aspects of the project, and it encourages the departure from standards towards innovation, amongst others.
Time-to-delivery savings	The private sector has a greater incentive to generate income as quickly as possible. Also private sector entities are driven by profit and are often accountable to shareholders who will ensure the profit margins are not affected by higher interest rates and income losses due to penalties caused by project completion delays.
Reduced capital demands on Treasury	This is particularly evident in infrastructure development, but it must be remembered that cost to the public

	sector could still come at a later stage when the infrastructure is transferred back. Maintenance and other operational costs must be considered.
The PPP process for a municipal service delivery for waste management	
One of the most important aspects of a PPP is the feasibility study, which consists of 9 stages	• Stage 1: Needs analysis • Stage 2: Technical options analysis • Stage 3: Service delivery options analysis • Stage 4: Delivery mechanism summary and interim recommendations • Stage 5: Due diligence • Stage 6: Value assessment • Stage 7: Procurement plan • Stage 8: Prepare and submit the feasibility study report to the council • Stage 9: Revisiting the feasibility study
How does it work?	
The PPP mechanism is a process required by Section (78) of the MSA that provide municipalities the opportunities to evaluate internal service delivery mechanisms, in order to assist municipalities in deciding on a mechanism that will assist in delivering a municipal service. First, the following need to be assessed and established: • **The benefits, as well as the direct and indirect costs.**	

- **The immediate and future capacity of the municipality to provide the crucial skills, resources and expertise required to provide the required service.**
- **The probable impact on development and creation of jobs, as well as employment patterns.**
- **The views of organised labour.**

Pros	Cons

• **It provides for different contract options:**
  o **A service contract ensures good standards.**
  o **A management contract is great for operational services and services that require any form of maintenance, where municipal waste management components are not able to due to a lack of internal skills or is simply not interested in doing such operations themselves.**
	• Initial costs can be higher e.g. transactional costs (such as high tendering costs) can be higher compared to normal procurement, higher capital costs due to private borrowing.

• **It can motivate municipalities to want to do more.**	• There might be concerns around public sector employees that will need to be managed by a PPP who is tasked with delivering a service at an existing public facility.
• **Conditions are attached to a contract that ensures municipalities**	

have some form of control over the outcome, e.g. a refund can be requested or payments can be withheld if work is not completed on time or if the work is shoddy.	
• **A PPP must be prioritised within the IDP's as an alternative mechanism.**	
• **Potential funding can be sourced from National Treasury (IDC and DBSA).**	
• **Municipalities can make use of an 'Expression of Interest' request inviting anyone who is interested to express new ideas of how to possibly solve the problem at hand. This will give the municipality a better perspective as to what is possible and who the potential role players may be. This is certainly a better alternative than to simply go the conventional route by placing a newspaper advert calling for potential partners.**	
• **Provide the opportunity for long term leases.**	
• **All parties of a PPP will be able to focus on what they know and do best.**	
• **Contractual agreements are designed towards performance-based outcomes.**	

• **PPPs are value for money.**	

Annexure C - Tender specifications based on the city of Cape Town's tender requirements

TENDER SPECIFICATIONS
General
DESCRIPTION OF THE SERVICES **The Municipality's, Solid waste Department would like to procure the services of a Contractor, for the handling, chipping and removal of green waste from waste facilities to achieve maximum diversion from landfill.**
SCOPE OF WORK **The contractor is expected to receive a variety of green waste, including but not limited to shrubs, brush and tree branches and clean wood waste at the facility for chipping purposes.** **The Contractor is required to inspect any material considered for processing for contaminants and remove contaminants in order to avoid undue wear or damage to his equipment.** **Tree stumps with a diameter exceeding 300 mm will be disposed of at various disposal facilities at the contractor's expense.** **The Contractor shall receive and stockpile the green waste in designated receiving areas.** **The Municipality does not warrant that materials to be processed will be free of contaminants.** **The Contractor shall be responsible for the safe disposal (NO LANDFILLING) of green waste.** **The contractor will be responsible for ensuring that the chipped material is reused and or recycled and provide proof of safe disposal.** **Processing of the chipped material off site is regarded as beneficiation, and as such, the Municipality shall not be liable for any costs associated therewith (e.g. composting costs).** **The Municipality shall also not be liable for any costs associated with the removal of rejected or contaminated material off site.** **The following form part of the Billing item: Directing of vehicles, assisting with the off-loading of green waste, handling, chipping and removal of chipped materials on site, including soft greens and disposal of rejected and contaminated greens.**

The Municipality takes no responsibility for any damage to the contractor equipment due to uninspected contaminated garden greens waste material.

SUPPLY AND COMPOSITION OF WASTE TO BE RECEIVED, PROCESSED OR TRANSPORTED

The Municipality makes no representation with respect to and does not warrant;

- **the delivery schedule during each day, or the quantity of green waste delivered each day or during the contract period as a whole or,**
- **the suitability of the incoming green waste for chipping purposes.**

The Municipality accepts no responsibility for any changes in quantities or composition to the green waste that may occur in the future for green waste delivered to any facility.

Any changes that may occur in the future shall not be grounds for the Contractor to seek any amendment to the terms of any contract agreement that is entered into.

SUPPLY OF INFRASTRUCTURE, EQUIPMENTS AND OTHER RESOURCES ON SITES

All infrastructure etc. provided by the Municipality, during the contract period shall at all times remain the property of the Municipality.

- **The contractor shall be responsible for the provision of office accommodation, ablution facilities and mess room facilities in compliance with the OHSA where such facilities are not provided for on site. The contractor is responsible for any service connection to be provided by the Municipality. No housing or sleeping facilities will be allowed on site for the Contractors employees.**

- **The Contractor shall provide for all equipment, furniture, fittings and fixtures required by the Contractors employees for providing the required services in accordance with the tender.**

- **The Contractor shall take full responsibility for the care and security of all of its property, facilities, equipment and his employees on the Employers (municipality) property and elsewhere and the Employer (Municipality) shall bear no responsibility in this regard.**

- **In the event of any occurrence of damage to the Employers property the Contractor shall in addition to any statutory requirement or other requirements contained in the Contract notify the Employer (Municipality) within 2 hours of the event by telephone and in writing or fax giving the circumstances, nature and an estimate of the loss or damage or liability.**

- **The Contractor will be responsible for any damage he/she causes to facility buildings, fences, gates, surfaces or other structures as set or established. These buildings, fences, gates, surfaces or other structures will be repaired and/or replaced to their original condition in accordance with the Employers conditions and specifications at the Contractor's expense.**

PROVISION OF A CHIPPER

The chipper shall be a model originally designed and built specifically for the chipping or grinding of green waste and should not be converted or modified machine from its original use. The minimum capacity out- put of the chipper shall be site specific, so as to meet the chipping requirements of specific site. At a minimum the chipper or grinder must:

- **Be able to process garden waste and reduce the material to a size not greater than 50 mm and shred branches and stumps to a diameter of 300 mm**
- **Be capable to process between** 50 and 150 **cubic meters per hour depending on the output of each site. (**Municipality will provide an estimation for sites output)
- **Have a discharge conveyor capable of discharging shredded material into a container or onto a stockpile.**
- **Roving Chipper/s and/or Loaders are only permitted within facilities of an area. No roving chipper will be permitted outside the awarded area.**

OTHER EQUIPMENT

The Contractor will provide at his expense, any other required equipment for operation at the facility, which may include:

- **Loader and/or Grapper**
- **Water bowsers**
- **Haul truck and container/s**

All equipment **will be models with sufficient capacity, designed and built specifically for the work it will be completing.** All equipment **and** plant **must be licensed.**
The Contractor shall ensure that loaders **is available on site to clear and** move unprocessed material **to stockpile** at all times **during storage phase in order to ensure safe and adequate public access.**
The Contractor shall provide and maintain **at the facility, all equipment, tools and machinery for the** efficient management **and** daily operation **of the plant. All** vehicles shall display **the name of the** Contractor **and shall be in** good condition, **clean and in good repair.**

N.B. The Municipality indemnifies itself against negligence and lost property of the contractor**.**

MEASUREMENT AND PAYMENT (NB! All Tenderers to note below)

Disposal Facilities/Transfer Stations (sites with weigh bridges)

- **The unit of measurement for material (mixture of chipped material and/or soft greens) leaving Landfill sites and Transfer stations shall be measured in** kilograms (kg) **due to the availability of the weighbridge facility.**

- **All Containers will be weighed at the Landfill sites and Transfer stations. Before loading. When leaving the site, the containers must be full. The difference between the weights will be deemed to be the weight of the chipped materials.**

Drop Off Facilities (sites without weigh bridges)

- **The unit of measurement for material (mixture of chipped material and/or soft greens) leaving all Drop off Facilities shall be measured in cubic meters (m^3) due to the lack of weighbridges on site, hence the measurement is volumetric. All containers to be used at these facilities will be measured and verified prior to commencement of the contract. These containers must be provided for by the Contractor, and dedicated to the contracted area.**

NB. No payment can be claimed for rejected, contaminated garden waste or unchipped material.

MONTHLY INVOICING

Administrative Process in effecting payment

- **All containers leaving the sites with chipped material must be of full loads.**

- **All loads** MUST **be physically checked by the driver and be verified by a Municipal Official (only the Senior Foreman and/or any designation above the Senior Foreman).**

- **The Senior Foreman/ Superintendent/ Senior Superintendent/ Head** MUST **counter sign the delivery note slip before leaving the loading area or a designate chipping site.**

- No invoice/s **will be processed unless the delivery note is attached with both signature of the driver and designated Municipal official.**

Disposal Facilities

- **The kilogram of chipped green material removed from the Landfill sites and/or Transfer stations facility and disposed of at a permitted and or licensed processing facility for the previous month multiplied by the rate per kilogram (kg).**

- **Each invoice shall be accompanied by a schedule detailing garden waste statistics on the number of loads, container sizes and quantities removed from the facility of operation supported by weighing certificate/ slip from that Disposal facility.**

- **Proof of disposed rejected/contaminated material from site must be submitted with the invoice accompanied by weighbridge certificate slips of the facility where the contaminated material is disposed.**

- **The kilogram of chipped green material removed from the Landfill sites and/or Transfer stations facility and disposed of at a permitted and or licensed processing facility for the previous month multiplied by the rate per kilogram (kg).**

Drop Off Facilities

- **The volume of chipped green material removed from the Drop Off facility and disposed of at a permitted and or licensed processing facility for the previous month multiply by the rate per cubic metre (m^3).**

- **Each invoice shall be accompanied by a schedule detailing garden waste statistics on the number of loads, container sizes and quantities removed from the facility of operation supported by delivery note from that Drop Off facility.**

- **Proof of disposed rejected/contaminated material from site must be submitted with the invoice accompanied by weighbridge certificate slips of the facility where the contaminated material is disposed.**

- **The tax invoice must be accompanied by a schedule detailing the number of containers transported and the volume thereof from each** Drop off Facility **for the period under consideration for payment.**

- **The volume of chipped green material removed from the Drop Off facility and disposed of at a permitted and or licensed processing facility for the previous month multiply by the rate per cubic metre (m^3).**

Payment shall be made in terms of Clause x of the Special Conditions of the Contract.

OPERATING HOURS

Work will be conducted during the facilities normal operating hours as detailed below. The garden waste chipping /processing facilities shall be open to the public to receive waste as follows:

- Summer Operational Hours: Mondays to Saturday 08h00 and 20h00
- Winter Operational Hours: Mondays to Saturday 08h30 and 17h45
- Sundays Operational Hours: 09H00 – 17H00 all year round

The facilities shall be open on all public holidays except the following public holidays:

- Good Friday
- Christmas day
- New Year day

NB!!! NO REMOVAL OF CHIPPED MATERIAL FROM THE DROP OFF AND DISPOSAL FACILITIES WILL BE PERMITTED OUTSIDE NORMAL OPERATING HOURS. THE DETAILS OF FINAL PROCESSING OR DETAILS OF COMPOSTING FACILTIES AND MASS OF THE CHIPPED MATERIAL ARE TO BE PROVIDED WITH EACH REMOVAL FROM SITE. THESE TIMES MENTIONED ABOVE DO NOT APPLY TO DISPOSAL SITES

The Municipality retains the right to amend the hours and days of operation if required. The service provider shall ensure that each operating drop off facility and disposal site awarded to them, their operating hours are in line with the facility's operating hours.

COMPLIANCE

All equipment **shall meet all applicable noise standards and shall employ suitable measures to control off-site odour nuisances to meet health regulations and criteria.**

All mechanical equipment **shall be made safe in accordance with the Occupational Health and Safety Act No. 85 of 1993.**

The Contractor shall comply with all necessary Acts, Ordinances, Regulations and By-Laws relating to the registration, insurance and general operation of its vehicles and the employment of its workers and shall pay all taxes, levies and duties payable in respect of all vehicles used and employees employed.

The Contractor shall ensure that all drivers and workers employed are properly trained for the work they are to perform and that all drivers are in possession of a current drivers licence appropriate to the class of vehicle being driven.

The Contractor shall ensure that at all times all drivers shall be available for inspection of such drivers licence.

The _ shall comply with all the rules and regulations of the disposal or processing facility for the safe disposal of waste

STAFFING

The Contractor shall provide sufficient on-site personnel to ensure efficient management, safety, operation, and maintenance of the equipment. In order to accommodate staff absenteeism for sickness and vacation, the Contractor shall ensure that additional personnel are available to provide continuous operation and maintenance of the facility.

The Contractor staffing requirements shall be over and above the minimum stipulated as required by the Municipality

The Contractors shall provide staff with protective clothing and Uniform in accordance to OHSA. Staff shall conduct themselves in a courteous manner acceptable to the Council at all times.

The Contractor must provide the necessary mess facilities (non-permanent structure) for their staff.

At commencement of the Contract, and regularly thereafter, the Contractors staff shall be made aware of the requirements and obligations at the facility for:

- **safe and correct procedures for operating equipment and other activities at the facility**
- **the permit conditions for the facility**
- **waste accepted and not accepted by the facility**
- **occupational health, safety and welfare**
- **emergency response procedures**

ON-SITE OPERATIONS

Method Statement

The Contractor shall submit a detailed written method statement, where applicable with the Review Activity Operation Plan, to the Employer.

The method statement shall include, but not limited to:

a) Details of method of chipping
b) Staffing requirements and equipment
c) Waste Receiving and Inspection
d) Contaminated Material Identification and Management
e) Methods of disposing of contaminated waste from the process
f) Storage and Transporting
g) Occupational Health and Safety Features
h) Operations Plan
i) Waste Accounting and Reporting Procedures
j) Billing and Compensation Procedures
k) Traffic Control
l) Noise Mitigation
m) Dust, Litter, and Vector Control
n) Environmental Controls

The Operations Plan shall provide contingency operating procedures that will take effect in the event of interruption of normal operations, including but not limited to:

(a) fires and explosions
(b) work stoppage by the Contractor's employees (RIOTS)
(c) equipment failure
(d) receipt of Unacceptable Waste

The Employer (Municipality) retains the right to reject any method or process which does not comply with or otherwise satisfy all of the requirements that are set forth in all of the laws, bye- laws, codes, rules and regulations applicable to such facilities that have been adopted nationally, provincially and by the Council.

Site Management

- ✓ **Incoming and processed material shall be stockpiled in designated areas.**
- ✓ **Incoming and processed material shall not be stored on-site for longer than 72 hour or 3 days.**
- ✓ **In the event that stored material creates unsanitary conditions or interferes with the operation of the facility, it shall be removed immediately.**
- ✓ **Penalties to the extent of** 30% of the tendered rate/kg **will be imposed for unchipped greens covering more than the designated/agreed area.**

Traffic Management and Access Control

The Contractor shall be responsible for controlling the movement of all vehicles within his designated area of operation at the facility.
The Contractor will provide informational signs, directional devices, barricades and fencing required for notifying others that the Contractor is working and for preventing unauthorized traffic flow within the Contractor's work area.
The Contractor will erect, move, place, relocate and maintain these devices as required. All signage and road markings shall be kept clean and legible.

Dust Nuisance

The Contractor's attention is drawn to the presence of dwellings on and adjoining the site which are vulnerable to dust nuisance that might arise from the Contractor's operations. Since most of the facilities are within the urban area, mostly light industrial and residential areas, suppression of noise and dust is a major factor. The contractor must ensure that any necessary measures be taken to ensure maximum suppression of dust and noise. It will be required for temporary infrastructure to be erected/constructed by the contractor, at his/her own expense, to be compliant with the site license and Environmental Operational Management Plan and all applicable legislation including, without limitation, all legislation relating to the protection of the environment and health and safety.

Furthermore, it is advisable that the contractor shall visit each site prior to tendering to assess current conditions, to identify additional requirements for immediate compliance, and also any possible future risk which should be costed and included in the tender rates.
The Contractor furthermore is required to take all necessary precautions, including watering where appropriate, to prevent dust blowing from raw or processed

material heaps and during the movement of materials in the process. The Contractor is to allow for the cost of this work in his tendered price.

General

The Contractor shall be responsible for all operations of all plant and equipment and work associated with the chipping of the green waste material, including, but not limited to, loading into the chipper, moving the chipper as needed on-site to access material, chipping and loading into own containers for transportation.

The Contractor's operations will at all times be compliant with the site license and Environmental Operational Management Plan and all applicable legislation including, without limitation, all legislation relating to the protection of the environment and health and safety. Inspections, reviews and approvals by the Employer or any other regulatory authority shall not diminish the Contractor's rights and responsibilities or create any Employer liability for the Contractor's operation.

The Contractor shall be responsible for cleaning any litter in and around the processing area and off-site which may be a result of the operations. The processing operations shall in no way hinder any other operations associated with the facility.

NB!!! Occasionally, the Municipality may require up to 10 tons of chipped material at no cost the Municipality to be utilized strictly for landscaping purposes.

MAINTENANCE

General

The Contractor will maintain and repair his equipment to the manufacturer's original recommended specifications. Equipment removed from site for an extended period shall be replaced with an equivalent type.

Mechanical Equipment

The Employer does not provide any on-site repair facilities for the Contractor's use.

The Contractor shall not do any major repair or maintenance work on his equipment at the facility without the written approval of the Employer. Repair work shall not interfere with the operations of the facility. The Contractor shall keep all equipment neat and clean, rust free and painted

The Contractor shall not store any fuels, fluids, lubricants, filtration devices and any other materials at the facility without the written approval of the Employer.

The Contractor will handle and store all fuels, fluids, lubricants, filtration devices and anything else that may contaminate the surrounding environment in an acceptable manner.

The Contractor must store and dispose of these materials in accordance with local, provincial and national legislation and regulations.

MARKETING OF MATERIALS

The Contractor shall be responsible for further processing and marketing of all output materials and be responsible for all costs associated with this function. The Contractor shall retain all revenues from the sale of output products.

ACCREDITATION

The Contractor may have to be an Accredited Waste Service Provider, in terms of the Municipality's Waste By-law. The Tenderer must ensure that throughout the contract period, the company maintains the accreditation status. Should the accreditation be revoked, the defaulting proceedings will commence

SIGNOFF

I reviewed hereby approve the Guideline for the management of Green Waste in the Western Cape

_____ _____

NAME DATE

DESIGNATION

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