UNIVERSITY OF KWAZULU-NATAL

TOWARDS A SUSTAINABLE AND INTEGRATED WASTE DISPOSAL APPROACH: AN ASSESSMENT OF WASTE-TO-ENERGY FEASIBILITY IN MSUNDUZI MUNICIPALITY, SOUTH AFRICA

By

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DECLARATION

I Boniwe Zulu declare that

i) The research reported in this dissertation, except where otherwise indicated, is my original research.

ii) This dissertation has not been submitted for any degree or examination at any other university.

iii) This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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To Him who is able to do the impossible, I give praise and honour

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LIST OF ACRONYMS

DEA	-	Department of Environmental Affairs
IDP	-	Integrated Development Plan
ISWM	-	Integrated sustainable waste management
IWMP	-	Integrated Waste Management Plan
IWM-DST	-	Integrated waste management decision support tool
MSW	-	Municipal Solid Waste
NEMA	-	National Environment Management Act.
NWMS	-	National Waste Management Strategy
SA	-	South Africa
SADC	-	Southern African Development Community
SDG	-	Sustainable Development Goals
Stats SA	-	Statistics South Africa
WtE	-	Waste-to-Energy

ABSTRACT

Industrialisation and business activities have seen increased economic growth in major cities and townships. Urbanisation is on the rise largely through rapid human migration from rural or outlying areas to urban areas in both global North and global South countries. Humans create solid waste. The complexity of general solid waste tends to degrade the environment. Global organisations such as the United Nations and its Sustainable Development Goals along with various national and sub-national frameworks seek ways of solid waste management. The insufficient management of solid waste is a palpable cause of stress to the environment, budget processes, community participation challenges, institutional arrangements, finance issues and unsustainable waste disposal. Therefore, this desktop study interrogates the research problem of handling solid waste management at municipal governance level in an urban setting. Some municipalities in different parts of the world implement waste-to-energy technologies to address solid waste issues. The municipal context studied in this mini-dissertation is Msunduzi Municipality, which is the capital of KwaZulu-Natal Province, South Africa. Msunduzi Municipality has an integrated solid waste management plan. However, it is yet to embark upon implementation of waste-to-energy technologies. Drawing upon secondary data, the objectives of this study were to determine whether or not waste-to-energy approaches can assist with providing sustainable solutions to waste disposal and energy challenges at the municipal governance level. The study further ascertained outcomes of waste-to-energy technologies employed by cities in different countries and to draw lessons from these jurisdictions that could benefit Msunduzi Municipality in developing waste-to-energy technologies.

This descriptive exploratory non-empirical qualitative study is underpinned by the critical constructivist philosophical paradigm. Whilst Msunduzi Municipality provides the case context, the case is municipal solid waste and the unit of analysis is energy; approaches to deriving energy from solid waste. The study employed a non-probability sampling strategy and a purposive sampling technique. Secondary data were collected by using relevant words and phrases to source literature from various search engines and by examining global, national and sub-national policy frameworks. Findings, conclusions and recommendations provide lessons for Msunduzi and other similarly situated municipalities. The results inform policy and praxis for municipal governance on the feasibility of adopting sustainable integrated waste management approaches and waste-to-energy technologies.

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CHAPTER ONE:INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction

The rising levels of waste generated in major cities and townships of different countries around the globe constitute an immense problem for the people and authorities in such cities. This problem arises as a result of the economic activities and the ever-growing population consequent to the migration of people to these cities. It goes without saying that this rising amounts of waste have negative impacts on the environment constituting health risks for human beings and the wider ecosystem. Hence, government in different contexts has tried to establish plans to manage waste in a sustainable manner (Argarwal, Chaudhary & Singh, 2015: 111; Singh, 2019:259). Consequently, numerous studies on how municipal authorities can find sustainable means of waste disposal have become prominent in recent scholarly works in the municipal governance and Public Administration discourses. This Chapter provides the introduction of the study and details the research problem in relation to section 1.2 and 1.3. The following sections of the Chapter looks at the broad and narrow research problem. The research aim, questions, objectives, justification and significance of the study also form part of this Chapter. The last portion in the very same Chapter considers the methodology, limitations, delimitations, key terms , definitions and lastly, outline of all the chapters in the dissertation.

1.2 Background and Outline of the Broad Research Problem

Globally, there has been a rise in the economic growth of major cities and townships of both developing and developed countries (Ghosh, 2019:2). Notably, this rise in economic growth is brought about by the industrialization and growing levels of business activities in these cities which have attracted lots of people to the cities looking to reap from the economic benefits therein (Ahsan, Alamgir, El- Sergany, Shams, Rowshon & Daudi, 2014:1; Chu, Wang, Wang & Zhuang, 2016:1). The above phenomenon has also created another problem – the economic activities and the rise in population have led to the increase in municipal solid waste (MSW) in these cities ((Argarwal, et al., 2015:106; Hoornweg, Bhada-Tata, & Kennedy, 2013:615; Moya, Aldas, Lopez & Kaparaju, 2017:286). There has arisen also the problem of depletion of energy, as both the economic activities and human population's demand on the limited energy source in these cities increase. As noted in extant literature (Pandey, Vyas, Pandey & Gaur, 2016:40; Perrot & Subiantoro, 2018:1), the problem for the municipal authorities then has comprised of how to sustainably tackle the waste disposal and the limited energy challenges.

Previously, the known method of waste disposal in some cities is often comprised of the use of landfils (Lai, Hensley, Krutli & Stauffacher , 2016:7). This method has seen the disposal of MSW in excavated lands. The issue with this method as noted in literature has been its unsustainability especially for countries with limited land (Godfrey and Oelofse, 2017:11). Also, the problem with landfil sites is the fact that they also constitute environmental health hazards for people. Other forms of waste disposal also exist for example the efforts of different cities to utilise the methods of reducing, recycling and reusing (3Rs) of solid wastes (Perrot & Subiantoro, 2018:2-4; Vaish, Srivastava, Singh, Singh, Singh &Singh, 2016:324). However, in recent times new efforts in developed countries to manage the problem of waste disposal and generate sustainable energy have resulted in the Waste-to-Energy (WtE) strategy which has helped in dealing with waste disposal sustainably, while at the same time using such waste as a resource for generating renewable energy for the cities (Moya, et al., 2017:287; Ouda & Raza, 2014:270). There have been some notable success stories with this innovation in waste disposal management in developed and developing countries.

South Africa as a developing country also struggles with the problem of rising levels of economic activities and population in its major cities and townships. The country also struggles with how to deal with the rising levels of waste in its various municipalities (Dlamini, 2016:2; Mannie and Bowers, 2014:427). Meeting rising demands for energy as a result of rapid urbanization and economic growth also constitute a problem for the country (Stafford, Cohen, Pather-Elias, von Blottnitz, van Hille, Harrison & Burton, 2013:16). The Stats SA (2018:1) report notes that South Africa's population by 2018 was estimated at 57.7 million and there have been high levels of migration to major cities of the country in particular cities in Gauteng, Western Cape and Kwazulu-Natal provinces. This obviously is a cause for alarm as these cities not only have to find ways of dealing with service delivery but also to solve the problem of the rising waste levels and how to do this sustainably. Additionally, these cities/municipalities have to grapple with the need to find solutions to the problem of energy needed to service the rising population. The need to find solutions to these problems, grounds efforts and researchers which engage the discourse on WtE methods and indeed the Integrated Waste Management Plans (IWMP) in South Africa.

The dissertation envisages that perhaps it is time to look to the WtE methods of waste disposal used in developed and developing countries. The South African government supports the development and the implementation of WtE methods viewed as a solution to the problems illustrated in the above background (Sagen, 2014:9). This method has the

potential of helping municipalities to tackle the MSW issue in a sustainable manner. Additionally, it could help municipalities to generate more energy from waste. However, it is noted that WtE technologies as they exist currently, are not South African inventions but are innovations tailored for use in other countries (Zhang, Haung, Xu, & Gong, 2015:14182). There are also other issues which have to do with assessing cost, maintenance capabilities, and adaptation of these WtE technologies for use in different cities (Matheri, Mbohwa, Beliad, Seodigeng, Ngila & Muzenda, 2016:2-4). Against this backdrop, the proposed study focuses on assessing the feasibility and or implementability of the WtE technologies in the Msunduzi Municipality. This study will ultimately explore some lessons which the Municipality could learn from the use and application of WtE technologies in other municipal contexts.

1.3 Narrow Research Problem

The South African Department of Environmental Affairs (DEA) has a responsibility for developing policies and strategies aimed at protecting and developing the country's environment (DEA, 2011:3-4). To what extent these legislative and policy frameworks on waste management in South Africa have been successfully implemented at municipal governance level, is a matter of contention. Suffice to say that the problem of waste management as seen within the global context also affects South Africa currently and there is need to find ways in which the country can solve the problem of rising MSW and at the same time deal with the energy issues at the municipal governance level.

Msunduzi Municipality (also known as Pietermaritzburg) is the capital city of the KwaZulu-Natal province on the eastern seaboard of South Africa. The city's latest population statistics stands at about 618 536 people (StatsSA, 2011:55). It is one of the developing cities in the country and in recent times Msunduzi has seen increase economic activities resulting in concomitant to rural-urban migration. This has also led to a rise in the population of the city and the subsequent effect of the rise in MSW. Currently, the municipality is generating 114 478 tons of waste per year and that translates to 9 540 tons per month (Msunduzi Municipality IWMP, 2014-2018:22). Moreover, the 2011 census in the country also reported that the number of households in the Msunduzi Municipality is around 169128 (StatsSA, 2011:55). According to the Municipality's Integrated Development Plan (IDP) report (2016/2017:1) approximately 86 000 of these households receive refuse removal services once a week and this includes businesses. About 35000 households from that estimate are made up of people living in informal settlements who receive waste disposal

services from cooperatives. This leaves a balance of 48128 households who are not receiving any form of refuse removal service from the municipality.

There is a need then to find ways of dealing with the waste disposal issue in the Msunduzi Municipality. As also existing in other municipalities in the country, a landfil site is the major way in which the city deals with MSW issue. At the above rate of rise in the amount of MSW from households in the municipality, the landfil sites strategy is arguably not sustainable. Firstly, this could be blamed on the scarcity of land and the competing demands for the same land for other municipal purposes like the establishment of cemeteries, human settlements and farming purposes (MSA, 2000:4). Secondly, the unsustainability of using landfil sites for waste disposal in the municipality is as a result of the fact that the DEA is not encouraging registration of new landfil sites. Moreover, some of them are being closed due to the impact of leachate in underwater and the soil composition (McAllister, 2015:27). As it stands, the municipality developed the IWMP in 2013/14 and was approved by council in 2014, which stipulated the life span of the landfil sites to be 6 years (IWMP, 2014-2018:7). The reality is that the 6 year period of existing landfil sites is almost up hence the need to find a sustainable waste disposal system for the municipality. The municipality needs to look at available options and precisely an option that will work for the municipality considering the geographical spread and the economic pressure that it has (Msunduzi IDP report, 2016-17).

As existing in other developed and developing countries, major cities and townships in South Africa are facing the twin problem of the rise in levels of MSW and dwindling energy resource. The responsibility of finding ways to solve these problems ultimately rests with local municipal authorities. This dissertation is a contribution in research to help municipal authorities to make proper choices. These choices will contribute in their effort at managing MSW disposal in a sustainable manner and at the same create more energy for the use of cities and townships in South Africa.

Thus, the main research problem which materializes from the trajectories of the above background centers on evaluating the feasibility and or implementability of the WtE approach in the Msunduzi Municipality. The results of the study are aimed at informing policies and improving praxis of MSW management at municipal governance level.

1.4 Research Aim

This study aims to assess the feasibility of utilizing WtE technologies, towards a sustainable and integrated waste disposal approach in the Msunduzi Municipality, South Africa.

1.5 Research Questions

The study asks the following research questions and seeks to achieve the objectives listed in 1.6, below.

1) How can waste-to-energy approaches provide sustainable solutions to the waste disposal problems at municipal governance level?

2) How can waste-to-energy approaches provide sustainable solutions to energy challenges in at municipal governance level?

3) What notable waste-to-energy technologies and key components (if any) are available to solve the waste and energy challenges in Msunduzi municipality?

4) What lessons can Msunduzi municipality learn from other jurisdictions regarding adoption of waste-to energy technologies?

1.6 Research Objectives

In light of the research problem and research questions, the objectives of this study are to:

1) Determine whether or not waste-to-energy approaches could assist in providing sustainable solutions to waste disposal at municipal governance level;

2) Discover whether or not waste-to-energy can assist with providing sustainable solutions to the energy challenges at municipal governance level;

3) Ascertain what available waste-to-energy technologies and key components (if any) could be utilised in Msunduzi municipality;

4) Explore available lessons from other jurisdictions regarding the adoption of waste-to-energy technologies from which Msunduzi municipality may benefit

1.7 Justification of the Study

The dissertation is done in order to find solutions to MSW disposal and energy challenges in the Msunduzi Municipality. The results of the research are envisaged to help inform policy and praxis for governance in the Msunduzi Municipality on the feasibility of adopting IWM approaches as solutions to the above challenges.

1.8 Significance of the Study

The increase in population and the rise in economic activity created an increase in MSW. In the countries mentioned in the study, energy sources seem to be a challenge. The information gathered in the writing of the dissertation at global level indicates that both MSW and energy are a challenge (Oelofse, Muswema & Ramukhwetho, 2018:2). The study is significant as it primarily seeks to contribute to sustainable solutions in dealing with both MSW and energy challenges. This will assist in existing literature and contribute to the wider research on municipal governance/public administration in South Africa. In addition, there is need to assess the feasibility of adopting WtE methods, envisaged to help local municipal authorities to fulfill their constitutional mandate and governance role of providing a safe environment while catering for the energy needs in these municipalities. The findings, inferences and recomendations of this work hopefully assist Msunduzi a case context and other municipalities (Photonics, 2014:1)

Furthermore, from the review of extant studies on MSW management at the municipal governance level, it was noted that as it concerns the selected context of the proposed study (Msunduzi Municipality), there is a dearth of studies on how to achieve efficient and sustainable MSW management, considering that the available MSW methods (specifically the use of landfil sites) in the municipality is no longer sustainable (Godfrey & Oelofse, 2017:5). The dissertation is important as it seeks to contribute towards meaningfull discussion at the municipal policy level (Masiya, Davids & Mazenda, 2019:1).

1.9 Research Methodology

Research methodology is an organized manner to solving a perceived research problem (Rajaseka, Philomnathan & Chinnathambi, 2013: 5). A group of methods and tools are made available to the reseacher through literature to ensure that this process happens. It consists of the following, designs, types, strategy, data collection tools, sampling, data quality control, data analysis and presentation (Mthuli, 2016:1). The design may be, qualitative, quantitative or mixed methods. On the one hand, qualitative research design can be defined as a means of describing metaphors, concepts and symbols (Creswell, 2014:19; Daniel, 2016:92). It seeks to explain occurrences in their character and in full description and qualitative research often involves secondary evidence (O' Neil & Koekmoer, 2016:2). Whilst on the other hand quantitative design places importance on numbers (Sukamolson, 2016:5) mixed method research design is a combination of both qualitative and quantitative methods (Creswell, 2014:215). The dissertation has followed a qualitative research design as it is a non-empirical study.

One of the critical aspects of a research project is to be cognisant of the aim or type of research with which one engages (Davis, 2014:72). Aims or types of research are broad categories that assist in articulation of the purpose of the research. They are exploratory, explanatory, descriptive, predictive, correlative and pragmatic research (Davis, 2014:72). The dissertation took an exploratory type of approach. Another component of research methodology is strategy, that can be defined as the vehicle to be used in conducting your research (Davis, 2014:15). The vehicle could be, in a case of quantitative research, experimental in nature or non-experimental surveys (Mthuli, 2016:1). With qualitative research designs, one can use as a vehicle or strategy, a case study (Yin, 2014:7). Scholars differ on whether case study is a research design or research strategy. For purposes of this research, case study is considered a strategy. A case is defined as an effort to appreciate an occurrence in its circumstances (Strydom & Bezuidenhout, 2014:179).

Data collection methods are the means with which the information is obtained. These could be surveys, interviews, documents, archival searches, or a combination of any of these or other methods. Quantitative research designs collect numerical data, qualitative design collects, for example, stories, words, images, symbols that assist in creating a deeper understanding of the occurrence (du Plooy-Cilliers, 2014:290). Mixed methods use both data collection methods. As part of its components research methodology also consists of sampling. Pascoe (2014:131) argues that sampling is the process of narrowing down the subjects that will be responding to your questions in a research. Whilst (Gentles, Charles, Ploeg & Mckibbon, 2015:1775) argue that sampling is a selection of specific data origins where data is collected to address the research objectives. The selection of a sample is done out of a population. There are parameters that need to be set out for the selection in a particular population identified (Pascoe, 2014:133). The dissertation is a non-empirical, non-probability purposive sampling has been implored, using documents that have been accessed from various sources (Etikan & Bala, 2017:215).

Data quality control can be defined as the ability of a research to be deemed as trustworthy (Koonin, 2014:253). In quantitative research data quality control is done through verification of validity and reliability of the process. There are four dimensions that make up trustworthiness and those are, credibility, transferability, dependability and confirmability (Koonin, 2014: 253). Credibility is referring to the accuracy of interpretation (Merriam & Tisdell, 2016:242). Confirmability is how the data that is collected is linking up with the findings. It talks to synergy. The relationship and the authenticity of the process undertaken between data collection method, data analysis and theory that is tying together the process, that is dependability. When the findings are applied to another situation that is similar to the study that is referring to transferability (Merriam & Tisdell, 2016:253).

Data analysis can be differentiated between quantitative and qualitative analysis. In quantitative dissertation, statistical analysis is applied so as to do away with guess work (Khan, 2014:206) and in qualitative data analysis, data is transformed into findings (Cronje & Bezuidenhout, 2014:229). This evidently includes, distinctive concepts such as, analysing data in relation to textual, iterative, hermeneutic, subjective, constructed and symbolic (Cronje & Bezuidenhout, 2014:229) The data analysis in relation to qualitative methods need to answer questions that are related to the concepts indicated above. This dissertation employed textual and content analysis to answer the research questions and to discover findings.

1.10 Limitations of the dissertation

Limitations of the dissertation are elements that are out of the control of the researcher (Theofanidis & Fountouki, 2018:156). The topic that is discussed in the dissertation is new in South Africa. There are many scholars that have worked on it, but at the time of writing there is no tracebale policy framework from government that is related to WtE for an example. This is then identified as a limitation to the inferences and the findings that have been made. Another limitation is that the concept of WtE is a non-South African concept, with some of the technologies that are also foreign to the country. This poses a challenge in terms of adapting the technology to meet the South African context.

1.11 Delimitations of the dissertation

Theofanidis & Fountouki, (2018:157) argue that delimitation is that which is created by the writer to achieve a set goal. The study is a non-empirical study. It therefore relied upon getting information from documents. The researcher/writer created parameters as a delimitation to avoid reading everything and writing without having such. The parameters that were created assisted in following a pattern that developed into a flow. This is further explained in section 3.10.

1.12 Key terms and definitions

Municipal Solid Waste is defined as the refuse that is collected from households, business and industry (Abdel-Shafy & Mansour, 2018:1276, Dehghanifard & Dehghani, 2018:313-314). It consists of various variables and is also including garden waste and building rubble (Hoornweg & Bhada-Tata, 2012:3).

Integrated Waste Management, Wilson, Velis & Rodic (2015:53) argue that Integrated Waste Management is a holistic approach in dealing with MSW.

A municipal Integrated Development Plan is a planning tool that all municipalities of South Africa need to have for purposes of providing a service to the community (MSA, 2000:5)

Waste-to-Energy, it is the changing of waste into energy using various mechanical processes (Ouda & Raza, 2014:273).

Sustainable Development Goals as developed by the United Nations sustainable program, are the goals that are developed for purposes of ensuring that poverty is eliminated through various long-lasting processes, among other purposes (Morton, Pencheon & Squires, 2017:81). A more detailed account of these definitions will be elaborated more in the body of the dissertation.

1.13 Chapter Outline

1.13.1 Chapter one: Introduction and Background to the Study

This Chapter introduces the dissertation. It presents the background and outline to the research problem and states the problem which the research tackles. Other preamble presentations in the Chapter are the research design, research aim, research questions, objectives and significance of the study.

1.13.2 Chapter two: A Perspective from Literature, Legislative and Conceptual Frameworks

The Chapter focuses on a broad review of existing literature related to the present work. Additionally, the conceptual and legislative frameworks which guide the study are presented and analysed in this Chapter.

1.13.3 Chapter three: Research Methodology

This Chapter is a presentation of the research methodology and approaches used in the study. Such methodological aspects as philosophical paradigm, research design, broad research approach, ethical considerations and limitations of the study are presented in the Chapter.

1.13.4 Chapter four: Data Presentation, Analysis, and Inference

This Chapter focuses on the presentation of secondary data generated for the research. The analysis of the data and its discussions are also presented towards answering the research questions with which the study concerned itself.

1.13.5 Chapter five: Conclusions and Recommendations

The Chapter presents the conclusions of the study and some recommendations made based on the research findings and conclusions.

1.13.6 Summary of the Chapter

The current study is in the scholarly disciplines of Municipal Governance and Public Administration. It interrogates an aspect of local government administration which centres on the need to ensure proper service delivery at municipal governance level, in this case, the provision of a safe and healthy environment. The Chapter serves as the preamble to the research. It has presented the main aspects of the study focusing on the background to the research problem. This Chapter also delineated the research problem, aims, objectives, questions, and significance of the research. The next Chapter will delve into literature perspectives on the related themes to the current study. It will also focus on the conceptual and legislative frameworks which guide the study.

CHAPTER TWO: A PERSPECTIVE FROM LITERATURE, LEGISLATIVE AND CONCEPTUAL FRAMEWORKS

2.1 Introduction

This study straddles the scholarly areas of Municipal Governance and Public Administration and contributes to the burgeoning research in these disciplines. Specifically, the study is situated within the body of research on the role of local municipalities in delivering public goods and services. As such, the study sees the need for local municipalities to ensure proper waste management, towards creating a safe and healthy environment as a governance and public administration issue. This Chapter presents a survey of available studies that looked at the themes related to the present study. The Chapter additionally presents the conceptual and legislative frameworks that guide this study.

The studies reviewed are comprised of global, African and South African contexts and looked at related themes such as: Municipal Governance and Public Administration; Solid Waste Management at Municipal Governance Level; and Waste-to-Energy as a Sustainable Approach at Municipal Governance Level.

2.2. Public Administration and Municipal Governance

2.2.1. Public Administration

Public administration in both developing and developed countries has undergone various changes based on aspects that could be linked to the economic status of the country (Sarker, 2016:180). These changes have created an opportunity for the community to either be aware of how governments operate or closed the door to such. Public administration is defined as a coordination of a combination of policies, frameworks, organogram, human capacity that are assigned to an institution for it to be able to perform its assigned functions (Thornhill, 2014:15). Public administration is interested in ensuring that there is a cordinated effort in the following fundamentals: economic viability of the country, participation of citizens in government relations, sustainable development, planning of infrastructure development and many more other aspects that create the intergral component of managing a state effectively and effeciently (De Wet, 2014:28). Performance management systems need to be developed to measure the institution for the better good in relation to service delivery (Msunduzi Municipality PMS, 2018:2), (Van Der Waldt, 2014:246). In South Africa, public administration is the responsibility of National and Provincial Government. The state is catergorized into 3 spheres that have an intergovernmental coordination (Malan, 2014:60).

How a country performs public administration is dependent on the form of state that has been decided in that particular country (Malan, 2014:55).

2.2.2 Public Administration in Developing and Developed Countries

As indicated public administration is a system that combines various aspects that will create an institution or state being governable. In South Africa, the state has a responsibility of public administration that manages resources that are distributed to both the provincial and local municipalities (Malan, 2014:60). There are various tools of analysis that are used to measure the implementation of public administration and these include amongst others, rule of law, political commitment, curtailing corruption and economic develoment (Sarker, 2016:188). The abilility for a country to implement administration to the benefit of the community that it serves is measured by the success of some of the tools of analysis indicated above. Administration in general has to be effective and efficient for the benefit of the community it serves (Buleca & Mura, 2014:163).

It is important to note that in public administration in developing countries, politics and the relationship to the economic trends is critical (Brinkerhoff & Brinkerhoff, 2015:224). As such, proper governance is an intergral part of the country's ability to benefit from donor funding. At times in some of the developing countries, some of the tools of analysis are not all met. Consequently, public administration does not perform to the satisfaction of its citizens. Included in the relationship of politics and economics is effeciency and effectiveness. As part of the fundamentals the state has a responsibility to ensure that the resources are used in an effective and efficient manner for everybody that has an interest in the performance of the state (Ho & Im, 2015:263). The state needs to be in a mode that is ready to assist in achieving its role in relation to ensuring that the mandate is being delivered (Sarker, 2016:1).

In some of the developed countries the state that has a responsibility of public administration consists of national government and sub-national government such as local government and public corporations (Buleca & Mura, 2014:162). Critically the state or government has a responsibility to ensure that, the community is provided with the services that are required. Amongst other issues that have a potential of cementing the provision of services is resources. Provision of resources has been enhanced in developed countries by innovations that include amongst others public private partnerships (Puppim De Oliveira, Jing & Collins, 2015:66). Since the success of public administration is critical, various public administration reforms have been introduced. These changes include, performance based budgeting (Ho & Im, 2015:271). Due to the reality that these changes that are

introduced are adapted from developed countries, developing countries are finding it difficult to adjust (Puppim De Oliveira, et al., 2015:69).

2.2.3 Municipal Governance

The study specifically focuses on governance and service delivery is seen as central roles for local municipalities, especially in South Africa. The focus in existing research has been to understand how local municipalities fare in their governance role of providing adequate and proper services to local communities. Numerous global and local studies focus on this, for example, Haque (2013:3), Ndreu (2016:5), Nkomo (2017:1) and Sebola (2015:2).

Haque (2013:1) examined conceptual frameworks of local governments, considering them as a fundamental aspect of public administration and governance in both developing and developed countries. A note made, is that local municipal authorities have a twofold aim of delivering goods and services to local communities, also being a political representation of the local communities in which they are established (Haque, 2013:2). Ndreu (2016:5) agreed with Haque (2013:2) that local municipalities owe their establishment to the crucial aim of ensuring proper public administration and representing the people. Conclusions from the study suggest that strong finance, good geographic and demographic base are necessary for local municipalities to carry out their public administration functions at local community levels (Ndreu, 2016:7-8). A good geographic area indicates that local government has clear dermarcated boundaries and that there demographics are known and catered for in planning process (Ndreu, 2016:7)

Focusing on the South African local government public administration context, Sebola (2015:1) looks at the nexus between municipal governance and service delivery. The study was of the view that local governments remain the central mechanism towards the delivery of basic services to the people (Sebola, 2015:1). The South African constitution has assigned this tier of government the task of providing services that are beneficial to the livelihood and general welfare of local communities. Relatedly Nkomo (2017:2) notes that constitutionally South Africa's local municipalities are ascribed the role of providing sustainable basic services to local communities, promoting socio-economic developments also promoting a safe and healthy environment. Conclusions from the Nkomo study suggest that there are positive views about the level of public administration at urban local municipalities.However, a notable 47% of the participants in the Nkomo study were of the view that the administration of the local municipality is in itself problematic (Nkomo, 2017:12).

The above studies looked at municipal governance and public administration. Local municipalities are carrying the burden of representing citizens from local communities and

more importantly providing proper goods and services to the communities, including MSW. From the South African context, existing studies as exemplified by Nkomo (2017:2) note that one of the assigned constitutional duties of local municipalities is to promote a safe and healthy environment. This task is achievable through the provision of proper and sustainable waste disposal methods. The extent to which South African local municipalities are to carry out this crucial task, remains an important area of public administration to explore. The present study hence agrees with the description of the governance and public administration roles of local municipalities and seeks to contribute to the discussion on how South African municipalities can carry out the task of delivering safe and healthy environment through sustainable waste disposal methods.

2.2.3.1 Service delivery

The Constitution of the Republic of South Africa (RSA, 1996) places the responsibility of service delivery in the door steps of local government. Service delivery can be defined as the ability for the municipality to provide services to the community that are delegated by the constitution (Masiya, Davidis & Mazenda, 2019:32). Service delivery forms part of municipal governance. Local community members expect the municipality planning and provision of services. The municipality needs to communicate with the community anticipated levels service delivery to avoid challenges at a later stage (Beyers, 2015:122). The consultation process as part of governance was brought about by the increase in population, socio-economic status and an increased literacy rate (Kariuki & Tshandu, 2014:800).

For the municipality to provide services to its constuency it requires resources and this includes funding. There are various forms of funding sources available to the municipality and those are, grant funding, equitable share (in the case of South Africa) and its own sources that include rates and all. Limited resources of local government have led to collaborations with funders to ensure that responsibilities are met (Kekez, Howlett & Ramesh, 2018: 243). In relation to South African local governemnt, there are functions that are implemented by the District municipality and those that are implemented by the local municipality. This is entrenched in the Constitution and the Municipal Systems Act. Local municipalities provide such services as road planning and construction and economic development. Local municipalities further provide community services like Traffic management, Security, Recreation and Facilities, Waste Management, Area Based Management, Financial Services, Corporate Services. Msunduzi municipality is a local municipality. However, due to its financial capacity in the district, some functions that are legally district municipality functions are performed by Msunduzi. Provision of Water and Sanitation services is an example.

2.2.3.2 Solid Waste Management at Municipal Governance Level

The current study, embedded in the growing body of study, revolves around the issue of MSW management in the municipalities and cities of both developed and developing countries. There seems to be great interest in available studies on the issue of the production of MSW, including the management of it in these countries and in South Africa.

Mishra, Mishra, & Tiwari (2014:396) focus on solid waste management in Yavatmal city in India. On the one hand, solid waste as a concept is termed useless and unwanted material from daily household activities in a community. Waste management, on the other hand, is understood as a discipline, which focuses on how to control and manage the generation, storage, collection, transfer, processing, and disposal of such useless materials from households (Mishra, Mishra, & Tiwari (2014:396). The techniques available for the city to manage waste include manual separation and landfiling. It is a recommendation that measures that are environmentally friendly should be available for waste management. Still on MSW management in India, Agarwal, Chaudhary, and Singh (2015:106) are of the view that addressing the issue of waste management and ensuring effective waste management initiatives require a stringent integrated and strategic waste prevention framework. Commentators suggests that the rise of solid is due to an increasing population and the rapid urbanisation in different global contexts. Managing this scenario globally and in India specifically has necessitated the use of some initiatives. The predominant initiative is the landfil strategy of waste management. This according to Agarwal, *et al*. is not sustainable in the end. The role of the non-governmental sector in improving waste management initiatives is considered in that study. Relatedly, Ahsan *et al*. (2014:2) examine municipal waste management in some cities in Bangladesh. That study identified what constitutes solid wastes and the different management steps to deal with such wastes (Ahsan *et al*., 2014:2). In the study conducted by Ahsan et al,(2014:3) also indicates that, the role of city authorities in solving the problem of solid wastes in the identified cities is deliberated.

Still on the Asian continent, for Chu *et al*. (2016:1) the focus was on MSW that had become a serious problem in China in the last two decades. This problem has resulted in significant negative effects on the environment. Hence, research in the field of waste management can shed light on tackling environmental issues. The Chu (2016) study found that the technological dimension has the highest effect on municipal health and that solid waste should be separated before collection. Political and economic dimensions were also prevalent followed by the socio-cultural dimension. Furthermore, on the issue of MSW management, Choi (2016:1) investigated the effectiveness of strategies used in Oslo, Norway. It is noteworthy that rising levels of solid waste generated by people daily and globally is a problem confronting all. The question of how to deal with this problem is a

worldwide issue (Choi, 2016:1). The Choi study further found that waste management as it existed in the context was effective. However, more revolutionised and improved waste management methods are necessary (Choi, 2016:118).

Turning to MSW management on the African continent, Yoada, Chirawurah & Adongo, (2014:1) assessed domestic waste practices, waste disposal and other perceptions about waste and health in an urban setting in Ghana. As per interpretation, waste poses a threat to public health and the environment, if there are no measures in place to manage it (Yoada *et al.*, 2014:1). Notably, also it is the understanding that waste has no intrinsic value that motivated the need for waste disposal. The Yoada study concluded that effective MSW management to prevent exposing people to diseases in municipalities demands a combination of several practices including proper public education, provision of communal trash bins, collection of waste (Yoada *et al.*, 2014:8-9). Tambe, Ayongwa, Ngwabie & Forbid, (2016:1) looked into the characterization of MSW in South West Cameroon and a plan for sustainable waste management in that context revised. For the authors, the volume of MSW generated had rapidly increased faster than available management strategies to cope with such an increase in waste production (Tambe *et al*., 2016:20). To solve the problem, there was a need to determine the availability of data on solid waste characterization, which is the first vital step in developing a cohesive solid waste management plan. The Tambe study found the existence of some variations in MSW composition, which had implications for waste management processes (Tambe *et al*., 2016:22).

Also focusing on the African continent, Nshimiyimana (2015:42) is of the conclusion that MSW management demands a collaborative effort between individuals, organizations, authorities and the private sector. The Nshimiyimana study assessed MSW management practices in a district in Rwanda and noted that MSW management practices are central in the environmental setup of every human settlement agenda in cities. Conceptually, the study understood MSW management practices as all activities done to manage waste from point of generation to disposal. The establishing of the solid waste management status and the design strategies to overcome waste management challenges also constituted objectives in that study. The Nshimiyimana study notes method and process followed from the time of collection to its disposal within the context. Private companies also contribute to MSW management in collaboration with municipal authorities. Linked to the Nshimiyimana study, Lai *et al*. (2016:6) assessed MSW management in the Seychelles. It was noted that MSW management constitutes a significant challenge for the country since the landfil strategy predominantly used is not sustainable. Rather, it generates greenhouse gases, occupies the limited available land and produces leachates which are non-environmental

friendly (Lai *et al*., 2016:7). The Lai study aimed to provide alternative approaches to waste reduction. Lai, et al. found that several stakeholders agree that the government should be responsible to place adequate policies to incentivize waste reduction in the country.

Coming down to the South African context, Mannie and Bowers' (2014:433) study is against the backdrop of the need for adequate basic services including MSW management services in the advent of democracy and transformation in South Africa. The Mannie and Bowers study concluded that selecting an appropriate waste disposal solution for South African municipalities remained a challenge. However proper waste disposal planning processes and some improvements in available human and infrastructural resources could help in overcoming these challenges (Mannie and Bowers, 2014:434). Godfrey and Oelofse (2017:3-7) presented a historical review of MSW management practices in South Africa from 1989 to 2017. The Godfrey and Oelofse study identified four stages through which the South African MSW management practices have undergone. The first stage was the era of utilizing landfil; the second stage was the time of recycling.The third stage saw the promulgation of new waste management legislation. The fourth stage was the age of the drive for extended producer responsibility. Sequel to the above study, Oelofse, Muswema, Ramukhwatho (2018:1) assessed household food waste disposal practices in South Africa using the case study of Johannesburg and Ekurhuleni. The aim of the study was to present data, which represents household food waste disposal for the country (Oelofse, et al., 2018:1-2). The Oelofse study also assessed the possibility of reducing food waste at household levels in South Africa.

Related to the Oelofse study on MSW management practices in South Africa, Gumbi (2015:1) notes that rising municipal waste mismanagement and its negative impact to the environment constitutes great environmental concern in developing countries including South Africa. The Gumbi study reveals patterns, practices, and trends concerning the issue of waste management and minimization in the Ekurhuleni Metropolitan Municipality. As part of its waste management and minimization strategy, the municipality focused more on waste management services and has not endeavored to balance this strategy with other waste minimization strategies (Gumbi, 2015:112). The study made recommendations to address this matter.

Fakoya (2014:123) assesses institutional challenges to municipal waste management as service delivery in South Africa. The study problematized waste management practices at South African local municipalities and described the link between inadequate waste service delivery and institutional arrangement challenges in the local municipalities. The Fakoya study found that the institutional challenges to waste disposal at the municipalities stem in part from personnel problems that result in ineffective waste management and sanitation

strategies at some municipalities (Fakoya, 2014:123-124). Certain recommendations to improve these challenges are vivid in the study. Additionally, Dlamini (2016:1) explores the role of the informal sector in the effort of recycling solid wastes in Johannesburg. Waste pickers are conceived as part of the informal sector.Despite their role in helping with waste management, the Dlamini study notes that the different urban development and planning policies in South Africa have not put in place measures to integrate this informal sector in the policy framework (Dlamini, 2016:8). The barriers to the integration of the informal sector in waste management are under investigation in the Dlamini study. Dlamini (2016:94) proposed a method for sustainable waste management in Johannesburg, which recognized the effort of the informal sector.

From the foregoing, it is clear that studies have focused on the need for proper MSW management in municipalities and cities globally and in African countries. A central point that emerges in the studies is the emphasis on how to manage MSW materials. It seems that most countries do adopt different methods of waste management based on contextual waste characterizations. From the South African perspective, waste management has predominantly been the use of the traditional waste disposal landfils, the informal sector and recycling. These waste disposal strategies have helped in the reduction of waste and in dealing with MSW in South Africa's local municipalities. Some constraints/barriers, which hamper the efficiency of these waste management practices have been determined. The studies have also notably offered some solutions to stakeholders in these municipalities. However, there seems to be a lack of interest among these studies to focus on sustainable ways of MSW, for example, the utilization of the waste-to-energy and the integrated waste management (IWM) approach. It appears that this is an opportunity not yet seized by South African municipalities. The current study hence, seeks to fill this gap by building on available studies. Specifically, this study assesses the waste-to-energy possibilities in Msunduzi municipality of South Africa by drawing upon lessons from other municipalities across different continents. Next, relevant legislative and policy frameworks are explored.

2.2.4 Policy Making and Policy Analysis

Making of policies is a critical part for any institution to be able to have guidelines on how to run or manage the institution. Policy making can be considered as a combination of various ideas, concepts, brain storming, that have a goal in mind in relation to driving a certain agenda home, (de Coning & Wissink, 2018:3), (Reddy & Govender, 2014:158). Policy making involves vigorous debates that will hopefully end at a desired outcome. Policy making is an integral part of good governance, for purposes of improving efficiency and effectiveness in public service (Reddy & Govender, 2014:159). There are various

critical stages that need to be followed in policy making including public participation. Effective and efficient public governance is guided by a precise policy making and provides guidance to implementation (de Coning & Wissink, 2018:4). Determination of the approach is a difficult process and use of available evaluation methods will assist in getting the best possible scenario (Cloete, 2018:189)

Policy analysis is an oversight process that is continuous to ensure that a particular policy is achieving its desired outcome (Ile, 2014:179). Public participation plays a big role in ensuring that the policy planned and implemented is effective for the desired outcome. Cloete & de Coning, (2018:35), argue that there are various models, theories and paradigms to policy analysis. Continue to say there are no commonly agreed upon method to policy analysis. Due to the fact that there are various models and there is no agreed upon approach to policy analysis, this then suggests that multiple methods need to be used to get to the bottom line (Cloete & de Coning, 2018:68).
The dissertation does not seek to look at policy making and analysis

2.3 Legislative and Policy Frameworks

The government of a country is guided by legislation that results from Acts of parliament at a national and by-laws at a municipal level. The South African government has a road map that has been created for purposes of the citizen to have an understanding of the laws of the country (Barnard, Barnard, Friend & Visser, 2003:2)

2.3.1 Global Policy frameworks related to MSW

Global and regional policy frameworks are a critical stakeholder in MSW and WtE. A look at the initiatives that have been displayed by this role player needs to come to the fore. Waste management is a global issue. Municipal solid waste is growing at a pace that is faster than urbanization (Hoornweg & Bhada-Tata, 2012:ix). This creates an environment where governments and municipalities need to look at various waste disposal options that will have a direct impact on both the environment and economy (Hoornweg & Bhada-Tata, 2012: 27). The United Nations (UN) argues that waste is a global issue as such it needs politicians to worry about making policy decisions on its proper management (Wilson & Rogero, 2015:1). Before discussing waste as a global issue, it is worth noting the UN Sustainable Development Goals (SDGs) as related to waste management. Figure 2.1 lists the SDGs.

Figure 2.1: Global Sustainable Development Goals (SDGs)

Source: (Morton, Pencheon & Squires., 2017:86)

SDGs are a set of global objectives that the United Nations (UN) has agreed that it will guide the world (Morton, *et al*., 2017:82). They from a set of agreements, indicating ways of ensuring amongst other things that people of the world are not going to be exposed to poverty. These goals link with MSW as there are those that have a direct relation with global waste goals as discussed in Table 1 above. There are 17 SDGs as tabled by the UN.

The global waste management goals have a direct link with the Sustainable Development Goals (SDG). When waste is not properly managed it has a negative impact on public health and on polluting the environment (Wilson & Rogero, 2015:1). It is then argued that there is a need for a holistic approach in ensuring that waste management is done properly (Wilson, 2015:268). There is a policy decision that needs to be taken in relation to policy development and the regulatory control at a national level to meet global imperatives. There is a global call by the UN to adhere to waste management goals. Table 2.1 links the waste management goals advanced by Wilson (2015:268) to the SDGs.

Table 2.1: Global Waste Goals and Sustainable Development Goals

Global Waste Management Goals		**Related SDG Goals**
Ensure by 2020	W1:Access for all to adequate, safe and affordable solid waste collection services.	3-Health for all 11- Safe Cities
	W2: Stop uncontrolled dumping or burning	3- Health for all, 11- Safe cities, 12- Sustainable consumption & production(SPC), 6- Clean Water & Sanitation, 14- Marine Resources, 15- Terrestrial
Ensure by 2030	W3: Achieve sustainable & environmentally sound management of all waste particularly hazardous waste	12.4- Managing all waste, 7- Access to Energy, 13- Climate change
	W4: Substantially reduce waste generation through prevention and all the 3Rs (reduce, reuse, recycle) and thereby create jobs.	12.5- The 3Rs, 1- End poverty, 8- Growth & Employment, 9- Sustainable Industry
	W5:Half per capita global food waste at the retail and consumer levels, reduce food losses in the supply chain.	12.3- Food waste, 2- End of hunger, 2- Food security

Source: (Wilson, 2015:303)

Global waste management goals are not only linked to the SDGs but both sets of goals also aim to ensure sustainability (Wilson, Rodic, Modak, Soos, Carpintero, Velis, Iyer & Simonett, 2015:6). World cities generate about 1.3 billion tonnes of solid waste in a year (Hoornweg & Bhada-Tata, 2012:vii). There is an indication that this will increase to 2.2 billion tonnes in 2025 (Hoornweg & Bhada-Tata, 2012:vii). Governments have a responsibility in creating a range of policy options to encourage waste management practices. These policies amongst other things can include, awareness, pricing mechanisms, change in procurement process to provide a better waste practice (Hoornweg & Bhada-Tata, 2012:31)

There are international organizations that have an interest on waste management. One such an organization is WASTE, in Netherlands (Scheinberg, 2010:1). The organization is arguing for availibility of the service to all citizens, affordability and ultimately end of waste. Their argument is that if government provides policy direction and finacial backup to municipalities, then waste will be affordable (Scheinberg, 2010:1) Also provide accsess to information on the waste streams for purposes of affording the recyclers an opportunity

to manage their quantities for economic purposes. Waste management at global level is regarded as a key to sustainable development and accessibility to communities.

Sustainable development can be defined as the ability by everyone to create a balance for the environment to produce effectively for everyone (Moyo, O'keefe & Sill, 2013:14). It involves food sufficiency, productivity and balance in the ecological phenomenon (Moyo, et al., 2013:14). Each individual has a responsibility towards ensuring sustainability of the environment.

The following section will describe National legislative and policy framework.

2.3.2 National Legislative and Policy Framework

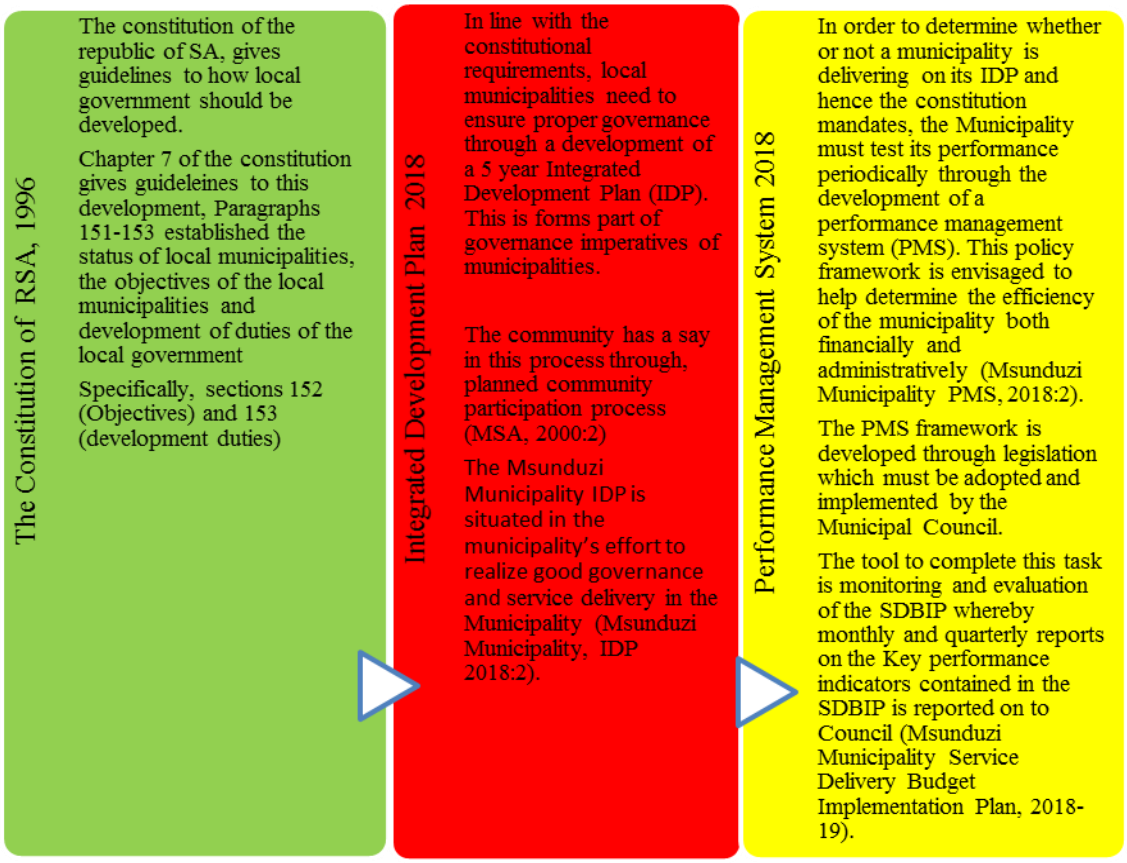
National government has a role to play in the development of legislation and policies. After the demise of Apartheid in South Africa, the dawn of democracy saw the need to redress the marginalization of the majority African people in the Country. The situation in former homelands called Bantustans during the apartheid regime was dire and saw the majority of African people living in poverty, squalor and dilapidated infrastructure (Onwuegbuchulam, 2018:9-10). The townships and rural areas of these Bantustans bore the brunt of the marginalizing system of government put in place by the Apartheid regime. The resources for the development of the homelands were limited, creating a situation in which people did not have proper service delivery and development (Frye, Farred and Nojekwa, 2011; Onwuegbuchulam, 2018:10).

Against the above backdrop, one of the visions of the democratic government was to look for ways to develop former homelands through the provision of adequate service delivery. The strategy was to engender a proper grass root governance model, which will allow the dividends of democracy to reach local communities. As a result, Chapter Seven (7) of the South African Constitution (1996) established the local government level comprising of municipalities.

The above legislative stipulations are central to the discussions in the current dissertation on municipal governance. These stipulations bring out clearly the legal framework in which local municipalities operate in their effort at governance and public administration, specifically in trying to realize service delivery and true democratic governance at local communities in South Africa. Linked to the IWM model, these legislative stipulations will guide the current study's discussions on the role, which Msunduzi Municipality authorities can play in facilitating the adoption of WtE technologies as a sustainable MSW management approach in the Municipality, considering lessons learnt from other contexts. The figure below (Figure:2.2), shows the constitution of the Republic of South Africa, Act 108 of 1996, Msunduzi Integrated Development and the Msunduzi Performance Management System.

The government of a country is guided by legislation that at times it gets translated into acts of parliament at a National and by laws at a municipal level. The South African government at a legislature level has a road map that has been created for purposes of the citizen to have an understanding of the laws of the country (Barnard, Barnard, Friend & Visser, 2003:2) The figure (Figure 2.2) that is presented below seeks to illustrate legislation at a National government level and policies that are guiding the municipality.

Figure 2.2: Legislative and Policy Framework



Source: adapted from (Schut, Leeuwis, & Van Paasen, 2013:2)

There are legal and policy directives that any government needs to follow, Figure 2.2 above is showing a snap short of such.

2.3.3 Sub-National Policy Framework

Sub National policy framework is the distinction that has been developed by the researcher to create a difference between National government and the Provincial government for the flow of the document. It combines both the province and the local municipality.

2.3.4 A view from the KwaZulu-Natal Province

In relation to seperation of powers, the department of Corperative Governance and Traditional Affairs (COGTA) is responsible for supporting municipalities in performing their functions. The national department of Environmental Affairs (DEA) has a responsibility to pass and ensure implementation of its policies through the Provincial office. The DEA in 1997 developed a national policy for integrated pollution and waste management and this was followed by a national waste management strategy (NWMS) which had a number of action plans (DEA, 2011:69-75). Both of these documents resulted in the development of guidelines for institutions that deal with waste to develop IWMP. IWMP, advocates for a waste hierarchy in relation to prevention, minimization, recycling, treatment and disposal (Msunduzi Municipality IWMP, 2014-2018:12).

2.3.5 Local Government perspective, generally

Local government is a wing that is within COGTA as a provincial department. This department works as a support system to municipalities. The IDP is a planning document that is developed by COGTA, through its municipal governance directorate. The aim of the document is to ensure that proper planning for service delivery to communities is conducted by the municipality. Also, a performance management system (PMS) to ensure that, the planned programmes are evaluated in terms of implementation. There is also a tool that is called Service Delivery Budget and Implementation Plan (SDBIP), and this serves as a monitoring tool that will be realised when PMS is conducted.

2.3.6 A municipal perspective

The municipality as a sphere of government being local government is governed by policies and systems for it to function. Amongst these policies include, IDP, PMS and IWM (this has been described in 2.5.1). In this section the two policies that have been mentioned will be discussed below.

2.3.6.1 Msunduzi Municipality Governance/ Service Delivery Policy Frameworks

Consequent on the constitutional stipulations as seen above each Local Municipality in South Africa is to develop policy frameworks, which will guide it in realising the constitutional demands. In order to ensure proper service delivery and specifically to promote the need for a safe and healthy environment, the Msunduzi Municipality has put in place different policy frameworks to guide its efforts. The Integrated Development Plan (IDP) and the Performance Management System (PMS) policy frameworks are discussed below.

2.3.6.2 Integrated Development Plan

The Integrated Development Plan (IDP) is the strategic document of the municipality that contains information pertaining to all plans of the municipality and its stakeholders; it contains information on the budget, the key performance service delivery; targets with timeframes as well as the process of implementing these targets. The IDP also contains the municipalities' three-year capital plan that has information pertaining to how the capital budget will be spent and projects thereof. The IDP must also contain the process plan of how the public (communities) will participate in the dealings of the municipality. Whilst developing and approving the IDP, the municipality must also approve the annual budget, which is to have a direct link to the performance targets of the Municipality as contained in the IDP. Annually once both the IDP and budget are completed, a municipality must produce the Service Delivery and Budget Implementation plan needing approval by the Mayor. Once the Mayor has approved the Service Delivery and Budget Implementation Plan (SDBIP), performance agreements must be developed and approved for the Municipal Manager and the Deputy Municipal Managers.

The IDP framework is central to the current study as it gives insight on the processes that guide Msunduzi Municipality's efforts at realizing proper service delivery and socio-economic development of the local communities. The current (2018-2019) IDP document as available from the Municipal website will be assessed to guide this study's discussions on Msunduzi Municipality's efforts to realize the constitutional mandates as previously presented (Msunduzi, 2018:5).

2.3.6.3 Performance Management System

The municipality has a legislative responsibility to develop a system that will test and report on its legal mandate and that system is called the performance management system (PMS), (Rodrigues, Fernandes, Rodrigues, Boroluzzi, Gouveza da Costa & Pinheiro, 2018:). In terms of Individual performance management, the municipality must develop and approve an Individual Performance Management framework to test performance at an individual level. The tool to achieve this is the development of a signed performance agreement that needs aligning to the SDBIP. Quarterly assessments need conducting. Reporting on the SDBIP as well as quarterly assessments form part of oversight function of the municipality and must serve the purpose of being an early warning system to reduce bottlenecks in the service delivery.

From the foregoing, it is clear that the PMS as a policy framework is central in evaluating local municipalities' efforts at ensuring service delivery at local communities. This framework is thus crucial for the analysis in the current study. The framework informs the discussions on Msunduzi municipality's financial and administrative capability to adopt and

utilise WtE technologies, towards sustainable waste management in the Municipality based on the IWM approach.

2.4 Waste-to-Energy as a Sustainable Approach at Municipal Governance Level

This study is also set in the growing body of research on Waste-to-Energy (WtE) approaches used at municipal governance level of different contexts to tackle MSW and Energy challenges. This approach notably is to help in transforming MSW to needed forms of renewable energy in some municipalities. On this, extant global studies have focused on the need for and benefits of WtE methods – There is a reckoning that WtE is an innovation in transforming the waste crisis in developed and developing countries. WtE is widely known as an additional form of realizing the need for a clean environment and economic development using sustainable energy. Extant research have also presented descriptions of the different available WtE technologies.

Ouda & Raza (2014:270) understood WtE strategies as solutions to the challenges of MSW management faced globally. The study was a review of the existing WtE technologies, current market status of the WtE and potential of WtE technologies. The study concluded by suggesting that the use of WtE methods in waste disposal is rising and identifying a proper technology for a particular locality will depend on certain factors including waste management maturity level, the composition of waste, geography, labor skill requirement, financial and technological capabilities (Ouda & Raza, 2014:273). Moya (2017:286) also agreed that MSW is a potential energy source for both developed and developing countries. The study examined MSW as a valuable resource for regenerable energy with some WtE technologies. The different WtE technologies is a cluster of biological treatment, thermal treatment, landfil gas utilization, and bio refineries. The study concluded after analysis that indeed MSW is a possible source of energy in both developed and developing countries, however technology transfer between developed and developing countries is lacking making it difficult for developing countries to benefit from this innovation in waste management (Moya, 2017:293). Furthermore, Pandey *et al*. (2016:40) noted that energy is source-able from waste by the conversion of such wastes into biogas, syngas or heat and this waste-to-energy method is sustainable. The study suggested that the use of WtE technology depends on geography, type of waste, demography and living standard of the people (Pandey *et al*., 2016:42).

Malinauskaite, Jouharab, Czajczynskab, Stanchevd, Katsoud, Rostkowskie, Thornef, Colong, Ponsag, Al-Mansourh, Anguilanol, Krzy_zynska, Lopezj, Vlasopoulus & Spencer, (2017:2014) are of the view that the use of WtE technologies ought to have a basis on their potential for environmental sustainability, however any chosen WtE technology should be

cost-efficient and socially acceptable. The study assessed MSW management and WtE context of the circular economy using the case study of some European countries. Remarkably for the study, transforming waste to energy could be central to EU's circular economy as WtE strategies have the potential of sustaining product value, materials and resources at the market level for a long time thereby reducing waste and rhesource (Malinauskaite *et al*., 2017:26). This resulted in EU member states being encouraged through certain policies to move away from MSW disposal to its transformation using WtE technologies. Focusing on an EU country, Cyranka and Jurczyk (2016:23) examined the potential of energy recovery from MSW using the WtE technology of thermal treatment boilers within the context of Poland. For the authors, the waste incineration boilers is a preferable WtE method because of its simplicity, reliability, and efficiency (Cyranka and Jurczyk, 2016:30). The study noted that this technology could hence be suitable to the Polish efforts at WtE since there are infrastructural developments that provides a good factor for enabling MSW management and generation of renewable energy in that country (Cyranka and Jurczyk, 2016:30).

Linked to the above, Perrot & Subiantoro (2018:1) explored the MSW management and the WtE prospects in New Zealand. New Zealand's government in its efforts to manage rising levels of MSW has notably adopted the 3Rs strategy of reduce, recycle and reuse waste (Perrot & Subiantoro, 2018:2-4). The view of WtE is that of an attractive and alternative measure to face the rising waste issue. Four WtE options for New Zealand where explored which included incineration, anaerobic digestion, gasification, and pyrolysis. The study concluded that anaerobic digestion plants are better for the WtE need of New Zealand since it is more environmentally friendly and economical waste (Perrot & Subiantoro, 2018:10). Vaish *et al*. (2016:328) gave a description of the MSW energy potential, the major WtE technologies, and their strategic implementation plan. Notably, the rising amount of waste generated in cities has the potential of causing environmental disasters. On the other hand there is continuous demand for energy supply. As posited by Perrot & Subiantoro (2018:1) the study also noted that scientific communities have sought new approaches to solve the problem of waste through the 3Rs strategy of reduce, reuse and recycle. For the study, there is still an urgent need to solve the problem of waste as well as meet the burgeoning demand for energy. It is a discovery that WtE methods have the potential of solving waste and energy crisis in urban cities, however, successful employment of such technologies will demand that appropriate objectives, planning and strategies render a timely completion.

Relating to the Asian context, Jain (2015:406) examined the ecological and the socio-economic dimension of the WtE management strategy in India. The study conceptualized WtE as the process of recovering energy (in the form of heat, electricity, and fuel) through

the transformation of waste, which cannot be, recycled (Jain, 2015:408). WtE processes include combustion, gasification, pyrolization, biomethanation and the tapping of landfil gas. These constituted a better alternative to the existing unsustainable waste disposal strategies as they solve a dual problem of disposing of waste better and help in providing energy in the form of electricity in India. The study further concluded that cost-benefit analysis in the study points to the efficiency of WtE plants in both cost terms and the lowering of poisonous gases emission, which is a welcomed development in the project of ensuring a clean and safe environment (Jain, 2015:410). Also using the context of India, Kumar, Fowler, Velis, Kumar, Arya, Kumar & Cheeseman, (2017:2) assessed the challenges and opportunities linked to waste management in that country. The available systems of waste management as obtained within the context of the study are noted to be inadequate and could not manage the increasing volumes of waste generated (Kumar *et al*., 2017:2). A suggestion that a move from reliance on existing waste dumping systems, which offer no environmental benefits, to a more sustainable WtE method that retains useful resources from waste, is of priority (Kumar *et al*., 2017:2). Kumar *et* al, (2017), brings forth this as an to ponder. On the proposed WtE method, the study concluded that the possibility of generating energy from landfil through the process of methane extraction or thermal treatment constitute a good opportunity for India. However, a key noted obstacle is the shortage of qualified engineers to manage the existing technologies and recommendations of the study that is looking towards overcoming this obstacle (Kumar *et al*., 2017:9-10).

Linked to Kumar *et al.*'s study Rafati, Boldaji, Khodadadi, Atafar, Hassan, Momtaz, Alizadeh & Mokhtari, (2016:175) used secondary data review methods to assess the challenges and opportunities of waste to energy in Iran. Iran like many other countries around is searching for appropriate, sustainable and cost-effective ways of replacing conventional energy provision with natural energy system. Waste has the appearance of becoming a potential source of energy production that is achievable through proper control of the effects of waste. The study further focused on the WtE technologies used to extract energy from waste and categorized them into two main methods, namely: biochemical and thermochemical methods. As it concerns Iran, the study concluded that most of the WtE methods are useable; however, it was central to choose the best technologies with the best functionality suited for the country (Rafati *et al*., 2016:182). This choice has a basis on certain environmental and infrastructural factors in the country.

Focusing on the African continent, Mwangomo (2018:1) explored the potential of WtE in the continent's major urban areas. The study noted that African urban areas generate many waste materials on a daily basis, which have negative effects on the environment and constituting human health hazards through the pollution of the air, water, and land

(Mwangomo, 2018:1). To solve this problem, African countries are devising and implementing proper waste management programmes which included WtE strategies aimed at converting waste to energy. The study agreed with views in existing studies that recovering energy from waste could be a better strategy of MSW management in African cities (Mwangomo, 2018:11). In addition, as it concerns the African continent, Hamad, Agil, Hamad &Sheffield, (2014:144) focused on the present and future possibilities in Libya's efforts at transforming solid wastes into renewable energy. For the authors solid waste constitutes a huge possibility for renewable energy (in the form of biomass) development, considering the rapid expansion of industries and urbanization coupled with population grown in Libya (Hamad *et al*., 2014:144-145). The suitability, availability, and challenges of the needed WtE technology requiring examination and discussion. Part of the study's conclusion was that WtE systems are sometimes costly to procure and install and this constituted a major obstacle to the deployment and use of these technologies (Hamad *et al*., 2014:152). Additionally, Akhator, Obanor, and Ezemonye (2016:635) examined Nigeria's potential and capacity for WtE technologies in order to help the country in its electricity needs. A study of Swedish WtE technologies with a view to recommend the use of a modified version that suits Nigerians needs was undertaken. The study's conclusion suggested that, with proper support from the government towards WtE development in Nigeria, the country could follow in the footsteps of Sweden to solve its electricity problems through the transformation of MSW using WtE technologies (Akhator, *et al*., 2016:641). In Sweden waste is regarded as a reource, about 99% of household waste is recycled as energy. It is regarded as a WtE success story (Akhator, et al., 2016:637)

Stafford *et al*. (2013:15) set in the WtE discourse in South Africa. The study explored the availability of technologies in South Africa capable of generating energy and at the same time treat wastewater. Such technologies are also envisaged to produce the energy needed in the country through the use of WtE technologies and processes like gasification, generation of biogas and bioethanol, recovery of heat and microbial fuel cells (Stafford *et al*., 2013:16-20). The study also looked at the applicability of existing WtE technologies in South Africa's effort to transform wastewater into energy. The study concluded that anaerobic digestion WtE technology was more applicable as it has the benefit of net energy generation, less pollution and enables safe water reclamation from wastewater (Stafford *et al*., 2013:23).

Relatedly, Mutezo (2015:11) noted that MSWs are abundant in South Africa with the increase in population and urbanisation but the utilisation of these MSWs for the energy needs in different municipalities is not largely common. Different WtE options available for the municipalities are noteworthy in this study to include biochemical and thermochemical

technologies. The study identified the obstacles to the wide-scale use of these WtE technologies in the country and recommended among other points that South African municipalities should consider exploring promising WtE technology options suited to their context and needs (Mutezo, 2015:105).

Moreover, Maisiri (2016:1) evaluated WtE incineration technology plant and its viability in the city of Potchefstroom South Africa. The study noted that South Africa faces a power shortage because of an increase in the demand and the country's inability to generate more electricity as needed because of different logistics issues (Maisiri, 2016:1). This situation could be ameliorated using WtE technologies since global trends depict progress in the utilization of these technologies. Focusing on WtE thermal technologies the study is of the view that it has a possibility of achieving sustainable waste management goals in South Africa (Maisiri, 2016:13). Hence, the study did a techno-economic assessment of WtE grate incineration technologies, as it existed in Potchefstroom. The study concluded that WtE grate incineration technology has great potential and could support the country's initiatives towards generating more electricity (Maisiri, 2016:101). In addition, Matheri *et al*. (2016:1) noted that with the rise in economic development and urbanisation in South Africa, the problem of MSW is increasing necessitating a pressing need for WtE strategies. The study focused on the city of Johannesburg and explored some WtE technologies including incineration, pyrolysis, and gasification and composting were described (Matheri *et al*., 2016:2). A selection of anaerobic digestion technology happens as the preferred technology considering environmental, socio-cultural, technical and economic factors. The study further suggested that WtE is a key and economically viable route to South Africa's need for renewable energy (Matheri *et al*., 2016:6). In addition, experience from WtE development in the country could be an example for other developing countries.

The conclusions from the above studies summarise the views on WtE technologies used in MSW management and solving energy challenges at municipal governance level in different contexts. Notably, the reviewed studies agreed that WtE strategies and technology is a welcomed innovation in the waste disposal sector since it provides a sustainable way of MSW management. Also as agreed by the studies, utilizing WtE methods can lead to socio-economic development, since energy needed for such development could be created from readily available MSW. The studies also did agree that the use of WtE technologies will depend on different factors as obtained in different contexts. The current study will build on these extant studies but will specifically explore WtE technologies and possibilities at municipal governance level in a selected municipality in South Africa. On this, there seem a paltry of studies on WtE technologies including how they can be suitable for different local municipalities in the country. Mutezo (2015:1) which identified obstacles for local

municipalities to fully adopt and implement WtE technologies forms a point of departure for the current study. This study becomes relevant as it seeks to explore and assess lessons learnt from application of WtE technologies in other contexts and suggest ways to facilitate the use of WtE technologies at Msunduzi municipality.

This section has presented the preliminary review of extant literature, which focused on related themes to the research problems, and objectives of this research. Summarily, the selected studies reviewed here have looked at three major themes, which include Municipal Governance and Public Administration; Solid Waste Management at Municipal Governance Level; and Waste-to-Energy as a Sustainable Approach at Municipal Governance Level. The main views of this study are analysed and presented for consideration. Identified are the apparent gaps, which ground and justify the need for the current study. The next section will present the conceptual framework that guides this study.

2.4.1 MSW, Stakeholders views and the Environment

Waste disposal and its lack of proper management has a negative impact on the environment. The dissertation is looking at MSW and WtE, the environment then becomes an important component to bring to the discussion as it has a role to play in the sector. The environment can be defined in various ways. The first approach is to talk about the environment as nature in its natural landscape, without involving humans (NEMA, 2014:4). So, it becomes an environment in its natural habitat. The other definitions include human beings as also part of the landscape (NEMA, 2014:4). MSW that is not managed properly tends to have a negative impact on humans and the environment (Ejaz, Akhtar, Nisar & Naeem, 2010:379). The Southern African Development Community (SADC), argues that the environment is our home, handed over from generations (Moyo, *et al.*, 2013:14). Everyone has a responsibility for proper maintenance and care.

The impact could be a change in the biodiversity, human lives and the surroundings at large. The negative impact on the environment comes in when there is poor collection, resulting in dumping the waste (Aljaradin & Persson, 2012: 30). Lack of proper handling and transportation (Ejaz, *et al*., 2010:382). The manner or the site of disposal also if not properly managed may cause negative impact to both humans and the environment (Ejaz, *et al*., 2010:380). The picture below shows fire at the landfill site in Msunduzi municipality. The fumes are toxic and may have a negative impact on the health of surrounding communities.

Figure 2.3: Msunduzi landfill site on fire

Source: Researchers Pictures, October 2019.

The fire shown in figure 2.3 above shows a thick smoke. The majority of municipalities dispose of their waste at the landfill site. When the site is burning the fumes that are coming from the fire may be toxic and cause health challenges to the surrounding communities (WHO, 2015:14). There are construction standards in the landfill, that include lining of the landfill and building a leachate pump to ensure that there is no leachate sipping into underground water (Aljaradin & Persson, 2012:28). A lack of this mechanism may mean that the ground water is contaminated and thus affecting communities.

Biodiversity nearby the landfill needs to be protected from the landfill so as to ensure that impact is mitigated. The landfill needs to be covered with trees in its perimeter to ensure that a buffer zone is created for the surrounding communities. A properly managed waste disposal site creates an environment where both the nature and humans are protected. If not properly managed, they move into unclassified waste and that may be a cause for injury or ill health. In addition, there is an emergence of waste pickers in landfill sites. These people are making their livelihood out of recyclables. Lack thereof might create an emergence of diseases in the surrounding neighbourhood. The SADC has made a commitment of reducing contamination of air, water and land (Moya, *et al*., 2017:16). Also, the SADC calls upon

countries to address the environmental degradation, that has created a situation of making the environment to be a sink of pollution (Moyo, *et al*., 2013:16). It is a political choice to protect the environment and conversation must play its critical role (Millner & Ollivier, 2016:227). The picture below shows toxic fumes engulfing the community of Pietermaritzburg in Msunduzi surrounding the landfill site.

Figure 2.4: Fire fumes at the landfill site

Source: The Witness, 08 0ctober 2019.

Figure 2.4 above depicts thick smoke engulfing the sky.

Stakeholders views in MSW and WtE are a critical component of the process. The interest, power and political dispensation of the stakeholder may influence the view articulated in the subject matter (Phong Le, Nguyen, & Zhu, 2018:27). There is a growing interest amongst stakeholders in understanding of what is being done by those in power in relation to waste and conserving limited natural resources (Hornsby, Head, Ploumistou, & Ulgiati, 2017:1). A platform needs to be created for a dailogue for stakeholders to have a view in a project that will change a way of doing things (Kekezi, 2018: 31). The discussion above looked at the impact of MSW to the environment and stakeholder views. Below is a discussion on the challenges that are present in waste disposal.

2.4.2 Waste Disposal as a challenge

The dissertation has observed the challenges that are posted by waste disposal. The increase in population and economic capabilities has also resulted in the increase on the amount of waste that is being generated (Hoornweg & Bhada-Tata, 2012:1). In South Africa the country is growing in terms of population and industry, this results an increase in waste (DEA, 2009:7). The disposal of waste in the landfill is not the best solution, as it has a negative impact on the environment (DEA, 2009:7) There is lack of policy direction that has resulted in the none regulation of other solutions within the waste management hierarchy, being reduce, reuse and recycle (Wilson, et al., 2015:3). As mentioned in the document, waste management is a responsibility of municipality.

Disposal of waste in a landfill site has an impact on both humans and plants, it calls for proper management of the toxins that emanate from it (Vaverkova, Winkler, Adamcova, Radziemska, Uldrijan & Zloch, 2019:109). Ma, Hongting, Cao, Lu, Ding & Zhou (2016:590) also agree that the smell of waste disposed at the landfil site without proper management results in an attainable situation to communities. Challenges include breakdown in infrastructure, staff disputes, non-compacting inside the landfil. The lack of proper compacting develops lack of space to dump new waste. When there is no space inside, compactor drivers drop the waste outside as they are rushing for other areas to clear. When this happens, the municipality is then obliged to put more resources to deal with the consequences. MSW is a matter that needs urgent attention as it poses various challenges to communities (Zhu, Asnani, Zurbrugg, Anapolsky & Mani, 2008:1). Challenges that are posed by waste disposal have been indicated and now the dissertation will embark on the challenges that are posed by energy.

2.4.3 Energy Challenges

Scholars agree that there are challenges in energy, these challenges could be attributed to access to it. There are factors that can be a contributing factor to access to energy in the Southern region, they include socio economy, availability and proximity to natural resources (Diaz-Maurin, Chiguvare & Gope, 2018:110). Global South have a challenge in terms of exploiting other means of providing energy through the use of renewable energy, even importing such proves a difficulty (Diaz-Maurin, *et al*., 2018:110). Another challenge that has been identified is global warming and means of limiting such (Markosvka, Natasa, Duic, Mathiesen, Guzouic, Piacentino, Schlor & Lund, 2016: 1505). The manner in which energy is produced in many countries is contributing to the high levels of global warming (Markosvka, *et al*., 2016:1505). There is a call to reduce global warming through a decrease in use of the products that degrade the environment.

The SADC and the New Partnership for Africa's Development (NEPAD) are regional organisations concerned with matters of energy and the environment. The SADC argues that it is critical to decrease dependency for energy on non-renewable, mineral and chemical sources (Moyo, *et al*., 2013: 16). Also critical is the decarbonisation of the economy through use of less carbon driven entities (Markosvka, *et al*., 2016:1505). Decarbonisation can be achieved through a combination of efficiency, sufficiency and renewable energy mechanisms. The NEPAD has a revised action plan comprised of 9 sectors (NEPAD, 2010-2012:7). Central to this dissertation are 2 sectors, being, Infrastructure (Energy) and Environmental and climate change. NEPAD is agreeing that there is an untapped energy potential within the continent. Emerging is a need to search and promote clean energy sources. Global South has a responsibility to look for different forms of modern energy, like Biological methods (biogas) (NEPAD, 2010-2012:22). There are various challenges that are challenging energy, another one of them is energy security. In the South African context, load shedding has become a norm as energy is under threat. There is no clear definition as to where the treat is coming from as there are various ideas that are being shared informally. The next section will present the conceptual framework that guides this study.

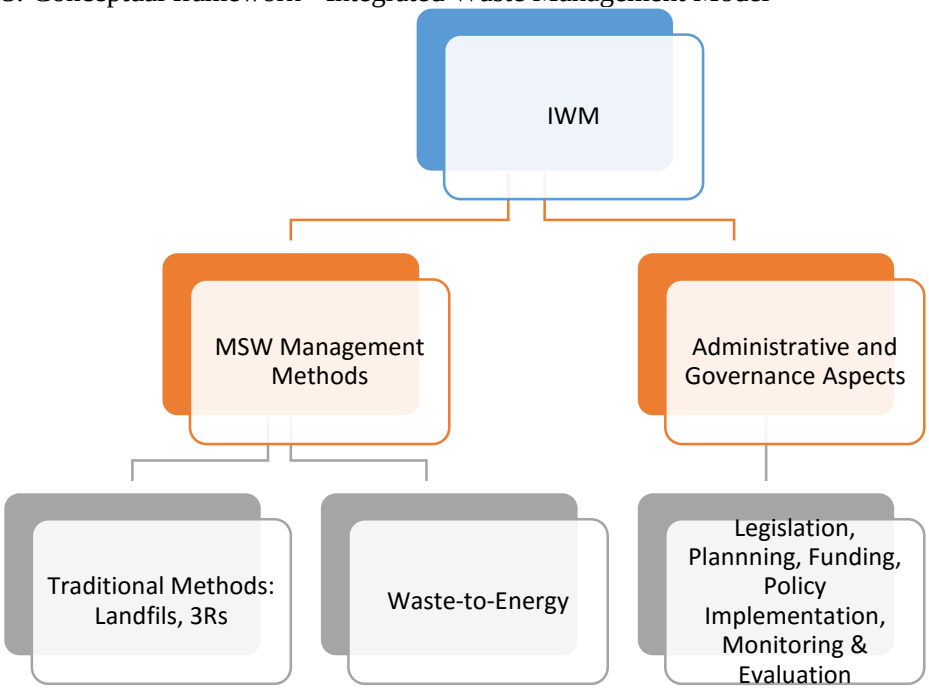
2.5 Conceptual Framework

A conceptual framework is a structure that is documented for purposes of graphically representing the concepts that forms part of the research (Adom, Hussein & Agyem, 2018:439). It creates a roadmap of the critical concepts that form part of the document. It assists in constructing the world view on the aspects to be discussed in the document (Adom, et al., 2018:439). It serves as a lense that is used to view the process that has been undertaken (Yamauchi, Ponte, Ratliffe & Traynor, 2017:26). It assists in creating an environment for the reader to be aware of the concepts that will be discussed in the document.

2.5.1 Integrated Waste Management (IWM) Model

As already stated, the document is embedded in the area of Municipal Governance and Public Administration and specifically on the role of local municipalities to deliver proper services including providing adequate and sustainable waste management system. The dissertation hence adopts the IWM model as its conceptual framework. This framework understandably comprises of two main variables: the combined use of different suitable MSW management methods and the administrative/governance aspects of MSW management. The representation is as Figure 2.5 below:

Figure 2.5: Conceptual framework - Integrated Waste Management Model



Source: adapted from, (Kiat Ng, 2013:282)

Figure 5 above indicates concepts in the dissertation. The centrality of the IWM framework and the justification for its use in this study is inferable from views in extant research on IWM. Debnath (2016:83-84) provides different understandings of IWM which explains the above diagram. Second, the interconnection of different waste management practices to ensure efficiency in waste disposal management is highlighted. This an approach which combines suitable traditional methods (landfils and 3Rs - reduce, reuse and recycle) to conventional WtE methods. It is a policy framework to improve MSW in municipalities. The study suggested that IWM enables businesses to consider waste management as a strategy to arrange every process in their business in such a way it minimizes negative environmental and social impacts (Debnath, 2016:96). Durgekar (2016:147-148) also agreed that the IWM model comprises the use of technological innovations, effective policy, supply chain integration, and participation. The suggestion is that, for better progress and effective management of municipal waste based on the integrated model, administrative and governance issues need explicit addressing, and this included the aspects of legislation, planning, implementation, and review (Durgekar, 2016:148). For Ikhlayel (2018:119) IWM as a concept represents progress in the controlled disposal of e-waste towards improving the environment and contributing positively to human health in developed and developing countries. Considerably, IWM is central in managing e-waste disposal but for this to be possible, region-specific I ssues need to be addressed (Ikhlayel, 2018:119-120).

Focusing on the context of South Africa, Sango, Basson, & Williams (2016:212) noted that because of the need to determine suitable WtE technologies and their impacts for the municipalities, the Green Cape Company developed the integrated waste management decision support tool (IWM-DST). The decision making tool was derived as means of assisting municipalities on an appropriate technology to use (Sango, et al., 2016:210). It becomes imperative for the municipality to have a full understanding of its waste full cycle and thus approach the WtE implementation in a holistic approach. This is directed at municipalities to help them in examining and adopting these technologies grounded on a full system method. A full system method is when the municipality is able to make a holistic decision on a technology and all its components, having taken into consideration, the challenges and advantages. Additionally, the tool could help the local governments to consider some crucial factors such as the cost of implementation of such IWM technology.

Summarily, the above discussion has tried to give an understanding of the IWM model to waste management. The understanding can be summarised in terms of a combination of different MSW management approaches with governance/administrative aspects of MSW management. Crucially, the model underscores the role of municipal authorities (in terms of proper administration and governance) in bringing about efficiency and effectiveness in any waste disposal approach. Considering these, the proposed study adopts IWM to assess the feasibility of implementing WtE technologies in the Msunduzi municipality. The IWM framework also helped the researcher to assess and interrogate the role of municipal authorities in facilitating the adoption of WtE methods in the context of of various jurisdictions so as to draw lessons for Msunduzi Municipality.

2.6 Summary of the Chapter

In summary, the central setting of the scholarly discipline of Municipal Governance focusing on a major local municipality administration issue includes amongst others, provision of a safe and healthy environment. This includes management of solid wastes. The main objective of the study is to assess how WtE methods of waste management can help in realizing service delivery through IWM. This Chapter has presented a review of literature, which looked at some of the themes related to the current study. Present in this Chapter, additionally are relevant global and regional policy frameworks as well as national and sub-national legislative and policy frameworks. This Chapter introduced the conceptual framework guiding the study before concluding with this summary. The next Chapter will focus on the research methodology used in this research.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

According to Saunders and Bezzina (2015:299), (Orla, et al., 2007) the research problem and objectives of a research inquiry are central aspects to consider when shaping research methodology. Thus, the choices associated with research methodology for this current project became a practical procedure in which the researcher selected methods and approaches that will help achieve the study's research objectives and answer the research questions. This study draws upon secondary data to explore the feasibility of utilizing WtE methods as a sustainable waste management practice in the Msunduzi municipality. This exploration is grounded on the IWM and other legislative/policy frameworks on waste disposal. Against the above backdrop, this Chapter delineates the research paradigm, design and strategy. It goes to the set forth sampling strategies, data collection methods, data quality control and data analysis methods. This Chapter presents ethical consideration and limitations of the study before concluding with a Chapter summary.

3.2 Research Paradigm

This dissertation is undergirded by the critical constructivist philosophical paradigm that posits that the construction of knowledge depends on what meaning different contexts attach to phenomena. On the one hand, critical constructivists believe that there is no such a thing as objective knowledge of the world since knowledge is relative and depends on the connotation that people in different contexts and time attached to a phenomenon (Adom, Yeboah and Ankrah, 2016:2). The constructivist paradigm is agreeable to the qualitative approaches since it purports that knowledge is a construct, through language and shared meaning (Orla, Willie, and Padraig, 2007:169). On the other hand, the positivist school of thought posits that, there is an objective reality of the world and to get to this knowledge, an inquirer needs only to adopt an empirical and logical approach (Kivunja and Kuyini, 2017:30). This school of thought hence grounds the inquiry in the empirical sciences, which utilise exact quantitative procedures in research and aims at absolutism and certainty (Kivunja & Kuyini, 2017:31). The above two positions have become central in the intellectual debate on the issue of construction of knowledge and how we get to know about the world and phenomena around us. The dissertation is not empirical/quantitative in nature and hence adopts the constructivist paradigm because it agrees with the qualitative research approaches envisaged to enable the researcher to address the main research questions and objectives of the study, using a logical but non-empirical approach.

3.3 Research Design

Scholars advance different definitions of what constitutes a research design. In the field of academic research, there are generally three broad research approaches/methods and they are, qualitative research methods, quantitative research methods, and mixed methods research. However, some scholars refer to these approaches as research designs (Creswell, 2014:12). Interestingly, still other scholars refer to a study being descriptive, explanatory or exploratory as constituting research designs (Van Vyk, 2012:7).

Turning first to qualitative, quantitative and mixed methods approaches as designs, these may be empirical or non-empirical. Empirical qualitative studies include collection and analysis of primary data. Non-empirical qualitative studies rely upon secondary evidence. In either case there is a focus on the use of words for data collection, analysis and interpretation. In either case, inductive data analysis is utilised in this research approach to understand participants' views and/or documents and texts that help address a research problem, often through the identification of patterns and themes (Creswell and Poth, 2013:65). Contrarily, quantitative methods presuppose a research approach in which mostly numerical data is used. It involves numerical data quantification and analysis towards determining the connections between variables or it numerically describes variables (Sukamolson, 2016:5). The mixed-methods approach combines aspects of both qualitative and quantitative approaches. It is a research method used when variables of a research inquiry are both qualitative and numerical in nature (Creswell & Plano Clark, 2011:1).

As aforementioned a study which aims to be descriptive, explanatory or exploratory is seen by some scholars to be research designs (Van Vyk, 2012:7). First, descriptive research focuses on observing and describing the variables of research and used in a research area in which there are existing data to be analysed and described (Shuttleworth, 2018:1). Second, explanatory research aims at understanding variables in a relatively new area of research inquiry. This research aims to shed light on relationships between research variables and help the inquirer to discover in-depth aspects of the new problem; often through cause and effect relationships (Yousaf, 2018:1). Third, exploratory research designs aim to identify the boundaries within which to locate a research problem and to inquire into an area about which little is known. The researcher may seek to engage in new areas of study or to gain information that may be useful for application elsewhere (Bhattacherjee, 2012:5).

This study adopts a descriptive, exploratory qualitative research design. Adopting this design is fitting for investigating a multifaceted social phenomenon such as IWM and converting waste to energy both of which have implications for the natural environment (Flick, 2018:11). To answer the research questions, the researcher describes and explores

how WtE approaches can provide sustainable solutions to the waste disposal problems and energy challenges by determining such activities in a variety of local jurisdictions on different continents. In this non-empirical research, secondary data is drawn from these various jurisdictions to help identify and describe lessons for Msunduzi municipality to move from mere IWM to WtE technologies. In other words, the author did not go out into the field to collect information, but information was acquired from existing documents including literature and policy and legislative frameworks, some of which are described in Chapter Two, section, 2.1 & 2.3.

3.4 Research Strategy

In any project that one is developing, one needs to have a plan as to how the required or anticipated outcome is going to be reached. Research strategy is that plan. Davis (2014:15) describes it as a vehicle, a how to and, Rahi (2017:2) argues that it is a means through which the researcher is collecting data (Rahi, 2017:2). How will the data be explained? It is critical to have clear objectives and questions along with a strategy to address them. Yin (2014: 4) argues that when a researcher seeks to understand complex phenomenon, the case study becomes a relevant plan to use. In relation to the work at hand the case is MSW, in the sense that, the challenge at hand is how it can be disposed of safely. The unit of analysis is Energy. Energy needs to come out of the waste that needs to be processed. In the section that is following below an in-depth discussion on the document analysis is delved into. The dissertation as means of collecting data has used analysis of documents and a case study.

3.5 Research Sampling

The current study is non-empirical in nature, focusing on utilising views, analyses and discussions in extant studies to draw conclusions that help in addressing this study's main research problem. A non-probability sampling strategy and purposive sampling technique were used in the process of identifying and selecting relevant secondary data for the analysis and discussions. Sharma (2017:750) notes that 'purposive sampling is a sampling technique that relies on the judgement of the researcher when it comes to selecting the units (e.g. people, case/organisations, events, pieces of data) that are to be studied.' Against this backdrop, the secondary sources selected for the current study underwent careful selection. The researcher was guided by their relevance and ability to help the researcher understand the parameters of the current research variables.

Additionally, the sampling of data sourced from secondary sources was guided by the saturation method implemented. This means that data for a study is looked up until such a stage where the addition of new information becomes exhausted (Nascimento, Souza, Oliveira, Moraes, Aguiar & Silva, 2018:229).

Moreover, the current study is conducted as a research in an academic institution, hence, utilised scoping review methods in which documents are arranged in categories for the purposes of reviewing them (Perrier, Morell and Pommier, 2017:206). The researcher utilised all the documents and secondary sources consulted and read for the purposes of this study as the population of this study. About 80 to 100 journal articles, 15 to 20 books, 20 to 30 internet sources including datasets, reports, thesis and dissertations, were consulted and were deemed by the researcher to constitute relevant sampled sources used to discuss the themes that concern this research. As such, a sample frame based on the documents and secondary sources consulted for this study was developed. This included sources on the following themes: public administration and municipal governance; solid waste management at municipal governance level; WtE as a sustainable approach to municipal waste disposal; WtE as a sustainable approach to energy challenges at municipal governance level; and IWM. The researcher drew words and phrases from these themes in the process of data search and collection. Some of the consulted sources were also used to discuss themes and concepts in the research methodology used in the current study.

3.6 Data Collection Method

As already stated, this research is non-empirical in nature. It is a desktop study (secondary research) relying largely on available literature, policy documents and data from secondary sources. Travis (2016:1) affirms that desktop research means reviewing existing research findings to gain a comprehensive understanding of the research problem on the one hand. On the other hand, it means using secondary data to help address that problem. Secondary data is efficient, powerful and is accessible, it provides for an ability to conduct a best practice overview (Greenhoot & Dowsett, 2012:3,5). This type of data creates an environment where the researcher can analyse, replicate existing studies whilst finding new questions to ask (Greenhoot & Dowsett, 2012:5). It provides an opportunity for a wide range of comparisons and contrasts. Thus it was critical for the researcher to create parameters for data collection.

Journal articles are the first set of data in use, followed by books, magazines, newspapers and internet pages. The data search was done utilising different research portals including but not limited to Ebscohost, Sciencedirect, Elsevier, Google scholar and Google search. Search phrases/words included, Municipal governance and public administration, waste management global perspective, waste management in South Africa, WtE approach, and integrated waste management approach.

The aim was to present, analyse, interpret and discuss these sets of data towards answering the research questions and reaching the objectives of the study. Cheng and Philips

(2014:371) note that the apparent advantage of secondary research is its cost-effectiveness. This grounds the justification for the use of this research approach. Since the approach was non- empirical it provided an opportunity to generate an overview of best practices employed by various municipal jurisdictions in different countries, regions and continents (Greenhoot & Dowsett, 2012:6). Moreover, the use of desktop research is justified since it agrees with the qualitative approach chosen for the proposed study.

In going about collecting books and other secondary data, the researcher took measures to only find and use relevant sources to help in the analysis and discussions in the study. Parameters worked as a guide to delimit the study on MSW and IWM as it pertains to leading toward WtE approaches and technologies. Setting parameters in place also generally took into consideration that the current study is a short dissertation, with a limited scope in terms of length (number of words considering subject credit 96C) of the project and the time and other resources available to the researcher to complete it.

3.7 Data Quality Control

Koonin (2014:253) argues that quality control in qualitative research refers to trustworthiness and has four scopes to it. These scopes are dependability, confirmability, credibility and transferability (Koonin, 2014: 253). In qualitative research such as this, ensuring trustworthiness is an important aspect in consideration under the theme of quality control. For Shenton (2004:63-64) in addressing credibility in qualitative research, the researcher's focus on establishing that a factual picture of what is being studied is presented. Similarly, ensuring trustworthiness in qualitative research entails that the researcher striving to establish confidence as a researcher and showing that the research findings are honest (Anney, 2014:275). This includes describing the step-by-step procedures of collecting and analysing data as explained in this Chapter.

To address the issue of trustworthiness in the proposed research, the researcher used the triangulation method (Anney, 2014:279; Korstjens and Moser, 2018:120). However, rather than using the triangulation method through different sources of evidence, this study triangulates experiences about SWM, IWM and WtE approaches and technologies by triangulating that which is occurring across various jurisdictions. Using this tactic is valid since this research is desktop based and utilises available research. The aim was to source sufficient data from different countries that focus on the research variables and then compare and contrast these views as different sources that offer suggestions for Msunduzi Municipality

3.8 Data Analysis Method

The secondary data generated for the proposed study is assimilated using a combination of textual analysis and content analysis methods. Textual and content analysis have a distinguishing fixture and that is they both analyse textually (Bezuidenhout & Cronje, 2014: 233). The idea is that data from such documents is evaluated and interpreted to gain understanding towards answering the research question. In data analysis the researcher is trying to make sense of the data collected, this involves, reducing, consolidation and interpretation (Merriam & Tisdell, 2016: 202). The data analysis method used in the dissertation is a textual analysis and content method. Mckee, (2001:2), cited in (Bezuidenhout & Cronje, 2014:230) sights text as significant because it holds critical meaning that needs to be guided. Braun & Clark (2013:134) argue that this method can be divided into two types, one is participant-generated data and pre-existing data. Pre-existing data is generated from secondary data. This form of data analysis requires tolerance and guarding against ambiguity (Merriam & Tisdell, 2016:201). Participant – generated data are, journals, diaries, memos, and any document that a participant has kept in relation to the subject matter at hand of that study. Content analysis is the determination of certain words or concepts in a text. Words and concepts that have been identified are illustrated in section 3.6.

When a researcher is analysing data the end product is to come out with findings. Having used the 2 methods as indicated in section 3.8, a process to bring findings is as crucial as data anaysis. Triangulation has been used in the dissertation to achieve the findings. Triangulation is a terminology used in aircrafts and maritime (Ashour, 2018:194). It can be defined as the use of diverse probing methods applied in the same occurrence to achieve results in a known point (Ashour, 2018:194, Farquhar & Michells, 2016:327). In the data analysis and findings of the dissertation, continents, countries, jurisdictions and municipalities were used in probing various outcomes. This is demonstrated in Chapter 4, in the following sections, 4.3, Tables 4.3,4.4, 4.5,4.6, section 4.4, Tables, 4.7,4.8,4.9, section 4.5, Table 4.10 and section 4.6, Table 4.11.

3.9 Ethical Considerations

The consideration of certain ethical issues in research is very important since it helps in ensuring that proper methods used in the study safeguard against exposing research participants to any form of harm (McKenna and Gray, 2018:147-148). Hence while conducting research (especially empirical research) there should be a consideration of proper ethics and the researcher needs to abide by some ethical codes and principles. These include informed consent, protection of privacy and confidentiality, beneficence and non-maleficence (no harm) (Fouka and Mantzorou, 2011:3). Since this study is not empirical in nature, it obviates the above ethical concerns inherent in empirical researches. The study does not involve participants to collect primary data through interviews, focus groups or in other ways.

However, the researcher was required to apply for ethical clearance from the University of KwaZulu-Natal's Ethics Committee. That committee had to determine whether the data to be collected was in the public domain and therefore entitled to an exemption from the typical ethical clearance processes and procedures. The committee approved the exemption and it is attached as an annexure in the dissertation. Ethical issues relating to the integrity of the method of this study was considered in section 3.7 on data quality control.

3.10 Delimitations and Limitations of the Study

There are delimitations and limitations associated with this study. Delimitations are within the control of the researcher and limitations are outside the control of the researcher (Theofanidis & Fountouki, 2018:157). As to delimitations, this study is limited in its scope in engaging in the discussion of municipal public administration and the need to find solutions to waste management issues in different municipalities of South Africa. The study is delimited to the use of identifying and exploring best practices in various jurisdictions with a focus on drawing lessons for Msunduzi Municipality. Moreover, this study is a short dissertation and hence limited in its latitude to assess the research problem and sustainable solutions elsewhere to shed light on improving MSW, IWM and WtE approaches and technologies with Msunduzi Municipality as a case context for possible adaptation of best practices discovered elsewhere. It is worth noting that the choice of Msunduzi Municipality is purposeful since the researcher resides and works in this municipality. The choice is justified since the researcher seeks to assist the municipality through this research to tackle its waste management problem.

Turning to limitations, this study did not receive independent funding which limits the resources available to conduct this research. There was limited time to complete the study as the researcher dealt with many competing obligations whilst working on this dissertation.

Next, the study could be perceived as methodologically limited. Conducting a descriptive exploratory qualitative research study utilising data from secondary sources means that the study is limited to pre-existing evidence. However, this is not necessarily a limitation when one reflects on the value of determining how municipal governance of solid waste and WtE initiatives are applied elsewhere before determining how to undertake this in Msunduzi Municipality. The use of analytical skills is very dependent on the skills of the researcher and researchers must guard against bias. The researcher acknowledges that the study may be limited in relation to studies that align with the conditions and context in South Africa. To upscale her research and analysis skills the research attended a series of workshops convened several times a year by the supervisor. In addition, the researcher engaged in a great deal of independent reading about research methodology. The researcher honed her

research skills abilities by critiquing the work of other masters and also doctoral students during the supervisor-led workshops and at times external to the workshop between students in the research collective. To minimise researcher bias, the researcher endeavoured to justify and substantiate research methodology decisions and deliberate findings and conclusions using credible sources. Additionally, the use of saturation methods (section 3.5) and the use of triangulation of jurisdictions (section 3.7) helped in checking and overcoming the researchers 'possibility to lean towards bias or subjective inferences.

3.11 Summary of the Chapter

This Chapter gave a detailed description of the methods used in the current research. The researcher proposed a constructivist paradigm to ground the methodological approaches suitable for the purposes of the current inquiry. This Chapter highlighted that this descriptive exploratory qualitative study was non-empirical and designed to address the research problem, questions and objectives of the study. For the case study strategy, MSW was the case and energy (as it pertains to WtE approaches and technologies) was the unit of analysis. Data collection and quality control were determined by certain parameters and undertaken through the use of identified search engines, words and phrases. Since data for the study were comprised of secondary evidence, content and textual analysis were employed as data analysis methods. The Chapter went on to present aspects of ethical considerations and limitations and delimitations of the study. The next Chapter will focus on the presentation of data and analysis of findings.

CHAPTER FOUR: DATA PRESENTATION, ANALYSIS AND INFERENCES

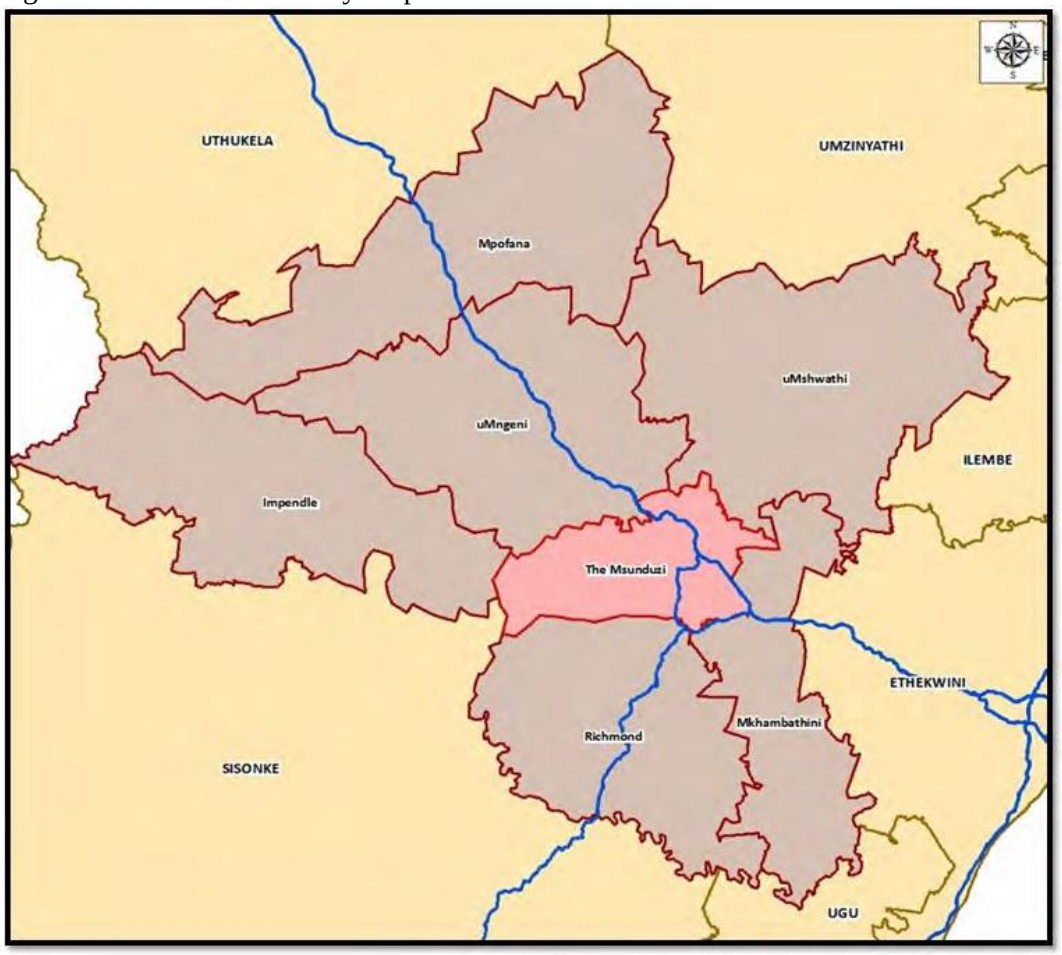
4.1 Introduction

To reiterate, this dissertation has set itself to assess the feasibility of utilizing WtE technologies, towards a sustainable and integrated waste disposal approach in the Msunduzi Municipality, South Africa. This Chapter focuses on the presentation of findings and discussions in the study. The first section of this Chapter presents and describes secondary data on the understanding of how WtE technologies can provide sustainable solutions to MSW disposal problems at the municipal governance level. The second part of the Chapter will focus on explicating how WtE approaches could provide sustainable solutions to energy challenges at the municipal governance level. The third main section explores available WtE technologies and key components that could be used at Msunduzi Municipality. The last main section will focus in on exploring possible lessons learned from other applications of WtE technologies that may benefit the Msunduzi Municipality. In other words, this Chapter is organised in line with the research questions and objectives. As this is desktop research, the strategy in this Chapter is to interrogate extant literature and to utilize views expressed by scholars to ground further discussions and conclusions towards addressing the research questions and objectives. Based on this, the presentations and discussions of views go together in this Chapter under themes guided by the research question/objective and the conceptual and legislative frameworks.

4.2. The Case Context of Msunduzi Municipality

Msunduzi is a municipality in KZN. It forms part of the UMgungundlovu district, as a local municipality. The municipality is in Pietermaritzburg, which is the capital town of the KZN province. The district consists of 7 municipalities, and some of them share the landfill site at a nominal fee. A large percentage of the district waste is housed with the municipality's landfill site. The figure below depicts the municipality in a map format.

Figure 4.6: Msunduzi Locality Map



Source**:** (IDP, 2018/2019)

The Msunduzi municipality map figure 4.6, shown as a local municipality within district municipalities in the Province of KZN.

The table below represents the demographics of the municipality as depicted in the 2019/2020 IDP. These demographics include an estimated growth in percentage.

Table 4.2: Msunduzi Municipality demographics

CATEGORY		**2011**	**Average Growth in %**	**2016**
Demographic profile	Population	618 536	1,1	682 000
	Household	164 625	2,0	181 584
Education Level	No Schooling	5.3 %	-5.1	3.8%
	Grade 12	17.0%	5.0	39.0%
	Higher	6.4%	5.1	14.7%
Age Profile	Youth	26.6 %	0.2	25.4%
	Working Age	68.4%	1.7	69.5%
	Elderly	5.0%	2.0	5.1%
Employment Profile	Employed	60.6%	2.7	65.8%
	Unemployed	39.4	-3.8	34.2%
Household Income Profile	No Income	15.8%	-0.9	12.1%
	Middle Income	22.8%	3.8	22.1%
	High Income	2.5%	13.5	4.5%

Source: (IDP, 2019/2020)

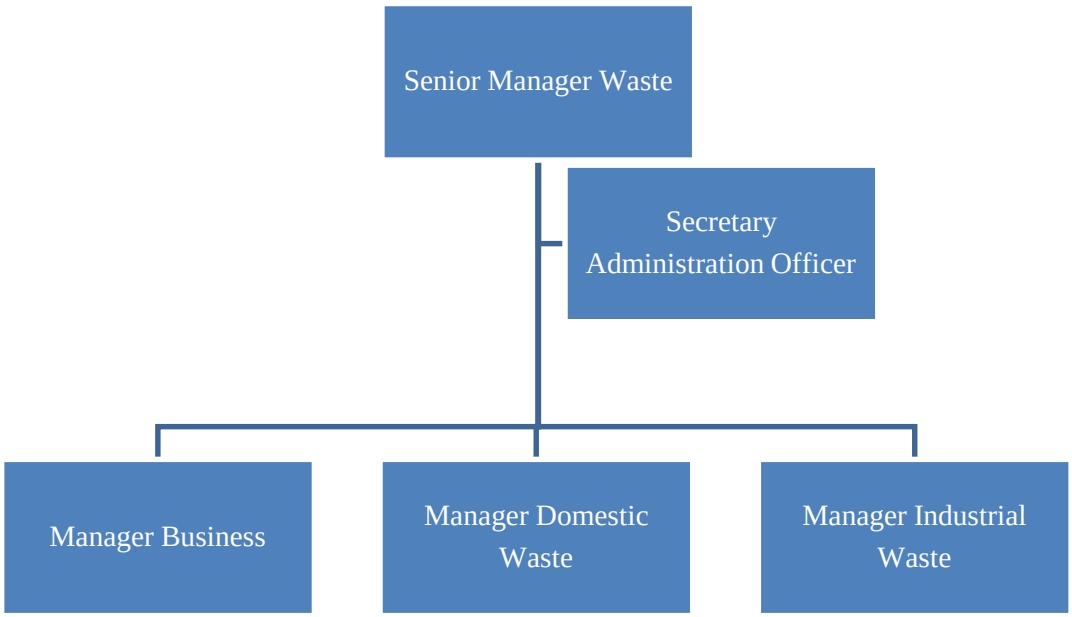
Table 4.2 above is the demographics within the municipality.

4.3 Waste Management in Msunduzi Municipality

The municipality consists of 5 departments namely, Corporate Business Unit, Corporate Services, Infrastructure Services, Community Services and Sustainable Development and Entities. Each of these departments has a General Manager and Senior Managers managing subunits. Community Services consists of the following business units, Area Based Management (ABM), Recreation and Facilities, Public Safety and Waste Management.

The organogram of waste management is as follows showing only the management structure:

Figure 4.7: Waste Management Organogram



Source: (IDP, 2018/2019)

The figure above introduces the management of the waste department with the Msunduzi municipality. MSW within Msunduzi municipality is housed with the waste management unit, within the Department of Community Services. The implementation of a WtE technology if decided upon will be implemented by the team depicted in the organogram. Community Services is led by a General manager and the above team reports to the general manager. It is imperative to illustrate the team that is critical in the MSW section. In relation the operations of the waste management unit, each manager has supervisors, foreman's, drivers and general assistance so as to perform their responsibilities at an operational level. The Msunduzi municipality has developed an IWM model that is seeks to implement in its area of jurisdiction. The fundamental principle in the implementation of the model is availability of resources. The Minister of Environmental Affairs has emphasised on supporting and promotion of sustainable waste management practises (Sango, *et al*., 2016:211). The municipality needs to have capacity in terms, ability to plan, understanding of their waste streams, financial know how and technical capabilities (Sango, *et al*., 2016:213). Developing and building a financial base, resources is critical for any municipality to implement IWM model (MacDonald, 2016:32, UNEP, 2009: 28).

The descriptions and illustration above shows the case content of the municipality, location, demographics and the waste management unit. It also touched on the importance of training and financial considerations in a municipality. The following section attempts to respond to the presentation, interpretation, analysis and findings of objective one.

4.4 WtE Approaches as Sustainable Solution to the Municipal Solid Waste Disposal Problem

Literature review notes that non-recyclable MSW constitutes a major problem and concern for municipal authorities in contemporary modern cities. On this, Ahsan *et al.* (2014:1) observed that; the problems that are linked with MSW management have advanced to an alarming dimension in the Global South. The population is growing at a high rate and the increase of economic undertakings in the urban areas of Global South combined with the lack of training in modern solid waste management practices complicates the efforts to improve the solid waste management services (DEA, 2016:282).

The question then is on how to manage this alarming and complicated MSW problem sustainably to provide a safe and healthy environment in different municipalities. Notably, answering this question and providing solutions to MSW have resulted in the use of different waste management methods, most prominently the use of reducing, recycle and reuse(3Rs), (Ouda & Raza, 2014:273; Perrot & Subiantoro, 2018:1). It was also noted from the literature review that most of the waste management methods used at municipal governance levels are not sustainable. The use of landfills also was noted to be a strategy mainly used to manage municipal waste in many contexts (Lai, Hensley, Krütli & Stauffacher, 2016:97; Godfrey and Oelofse, 2017:4). This strategy is also seen as non-sustainable since it does not offer a safe way of managing gas emissions from landfills which in itself constitutes health hazards for humans and the wider ecosystem. Ouda & Raza (2014:270) are of the view that the main dedication of MSW management strategies is to the healthy management of waste to the communities they serve. The environment, aesthetic, land-use resources, and economic concern related to improper disposal of waste also form part of the responsibilities (Ouda & Raza 2014:270). Consequently, in recent times, it has been noted to provide the best possible way of managing the rising MSW in many cities. Ofori (2016:11) defines it as a process of generating energy from non-recyclable MSW, animal manure, agricultural by-products, and farm-based wastes as well as some industrial and commercial waste. This definition attempts to answer the question of how to manage MSW sustainably. WtE methods and technologies are hence noted to have been central in solving the problem of waste disposal in different municipal contexts.

Focusing on urban cities in Global South, Abdel-Shafy & Mansour (2018:1288) looked at waste valorisation as a WtE technique to manage waste. Waste valorisation is understood as a technique of waste management that integrates composting and anaerobic digestion technologies. In this waste, components are characterized and separated making it possible for different components of the waste to be utilised for energy. The anaerobic technic for the treatment and valorisation of Organic Solid Waste (OSW) is Organic Solid State Fermentation (SSF) which is used in managing household food wastes sustainably. In this technology, the food waste with high dry content is used to produce ethanol using SSF valorisation which helps in the bioconversion of the household wastes. Valorization is noted to help reduce organic solid waste. It has the advantage of being simple, cost-effective as income could be generated through other techniques related to this which includes recycling activities (Abdel-Shafy and Mansour, 2018:1288). Relatedly, four WtE technology options to manage waste sustainability were assessed in the New Zealand context which included incineration technology, anaerobic digestion technology, gasification technology, and pyrolysis technology. In section 4.7.1 to 4.7.3, these technologies will be further explained. These technologies were assessed to determine the more suitable one for the context. It was found that anaerobic digestion was a more sustainable waste management technology as it is environmentally friendly and cost-effective within the context, Table 3 below is indicative of such. Perrot & Subiantoro (2018:9) noted that within the New Zealand context using anaerobic digestion led to a more environmentally friendly way of reducing waste, however, it was also noted that reducing waste and recycling non-biodegradable forms of waste could help in augmenting the use of this waste management technology.

Table 4.3: WtE sustainable solutions in Oceania

Jurisdiction	**WtE technology**	**Nature of sustainable Solutions**	**What outcome has been recorded**
New Zealand: Auckland City, Christ Church, Masterton Davenport	Biological Thermal (Perrot & Subiantoro, 2018:9)	Environmentally friendly. Cost effective	Reduces waste and recycling is critical

Source: Researcher's data analysis

The table is an illustration of WtE sustainable solutions.

The Mass-burn/Incineration WtE technology is also identified to be a sustainable solution to managing waste in two municipalities of Santiago in Chile. The WtE technology is noted to be sustainable as it helps in the reduction of waste by converting about 1000 metric tons of waste per day. It produces about 600 kWh of electricity per ton of MSW (Weinstein, 2006:3). The technology is also sustainable as limited land space is needed for the

installation of the plant. Table 4.4 below is indicative of this. It is also noted to be cost-effective since 'the cost-benefit analysis indicated that at the assumed gate fee (tipping fee) of USD14/ton the project has a positive Net Present Value (NPV) of $18 million at a 9% discount rate (Weinstein, 2006:3). The use of technology is noted to help in processing 14% of waste in one of the municipalities and reducing the waste of the second municipality by 44% (Weinstein, 2006:56).

Table 4.4: WtE sustainable solutions in South America

Jurisdiction	**WtE technology**	**Requirements for sustainable solutions**	**What outcome has been recorded**
Chile, Santiago	Thermal (Weinstein, 2006:3).	The amount of space needed is minimal. Payment is minimal	Reduces waste and provides energy.

Source: Researcher's data analysis

The table above shows WtE sustainable solutions.

In the context of the United States, WtE technology identified as "conversion technologies" is fast becoming an option for many cities in the country. The conversion technologies comprise three closely related WtE technologies put together and they include gasification, plasma gasification, and pyrolysis. Notably, the WtE conversion technologies involve 'the super-heating of a feedstock—be it MSW, coal, or agricultural residues—in an oxygen-controlled environment to avoid combustion' (Seltenrich, 2016:107). The use of this WtE method to manage waste is accredited to be sustainable in that they produce cleaner emissions, produces flexible energy outputs, more efficient and more valuable than the mass-burn incineration method. Within the context, the notable outcome of the use of the conversion technologies includes the reduction of MSW to the extent that the amount of MSW that goes to landfills is greatly reduced. The technologies also result in the recovery of metals and inert slags (Seltenrich, 2016:108). Table 4.5 below gives solutions for North America.

Table 4.5: WtE sustainable solutions in North America

Jurisdiction	**WtE technology**	**Nature of sustainable solution**	**What outcome has been recorded**
United States of America: Los Angeles	Thermal (Seltenrich, 2016:107)	Produces emissions that are clean and not harmful to the environment	Reduces the amount of waste going to the landfill site.

Source: Researcher's data analysis

An integrated WtE strategy that comprises different recycling methods including Organic Waste-Bio Composting and Household waste-Biomethanation technologies are used in Pune Municipality in India (Soni, Patil and Argade, 2016:119). It is noted that the process produces a sustainable solution to MSW in the form of using organic waste to produce biodiesel and ethanol products as illustrated in Table 6 below. In this kitchen, wastes are separated and fermented to yield ethanol. The rest of the other non-biodegradable waste products are recycled and also used in a landfill site. It is noted that there are no leftovers of waste through this integrated process managed by the Municipal Cooperation (Soni, *et al*., 2016:125). The outcome from the use of these technologies shows the proper management of MSW from the municipality handled by Pune Municipal cooperation. Also, the use of the methods to transform biodegradable solid waste is noted to have the added potential of generating different levels (mega tonnes) of biodiesels, fuel ethanol and liquid manure (Soni, *et al*., 2016:119). These products are used as energy in boilers, generating electricity and used as motor fuels. Using the context of urban cities in Thailand the Integrated MSW management system is assessed as a viable option to manage MSW in the context. The integrated model is used in this context because it is noted that no one single method of MSW disposal can deal with all issues that are waste-related in an environmentally sustainable way (Kaosol, 2009:670). This is illustrated in Table 4.6 below. In the Integrated model strategy, the idea is to utilize different technological methods together which includes incineration, composting, anaerobic digestion and recycling. The combination of these technologies is noted to present a sustainable solution to the municipal waste disposal problem. It has incineration that produces energy; composting of organic wastes that produce fertilizer; anaerobic digestion produces energy (i.e. biogas); usable materials are recovered through recycling. The methods together reduce the final waste into a manageable amount of environmentally friendly products such as fly ash. The final product can be disposed to landfill (Kaosol, 2009:665). It was noted that using the integrated model of MSW management in Thailand is suitable as waste composition in the context is mainly made up of organic waste, paper, plastic, glass, and metal. The method helps to manage waste in the context of sustainably and cost-effectively. As demonstrated in table 4.6 below.

Table 4.6: WtE sustainable solutions in Asia

Jurisdiction	**WtE Technologies**	**Nature of sustainable solutions**	**What outcome has been recorded**
Indonesia: Gyanyar Municipality	Biological (Zurbrugg, et al., 2012)	Sorting of waste at source & Composting. Low cost, low technology & low risk	Reduced waste by 90%. Able to process 60 tons per day.
Thailand: City of Kitakyushu	Biological Thermal (Kaosol, 2009:670).	Using a combination of methods as they have found out that one can't sort out their challenges. Integrated waste management system	Reduce waste into manageable amounts.
Indonesia: Surabaya City	Biological (Premakumara, *et al*., 2011:457)	Various composting centers in the city. Encourage, reuse & recycle	Reduce waste by more than 20%
Pune Municipality in India	Biological (Soni, *et al*., 2016: 119)	Use of organic to produce diesel & Ethanol.	Non-biodegradable is recycled & some used at the landfill site. Minimizes waste.

Source: Researcher's data analysis

Related to the above, Surabaya City, in Indonesia is noted to have adopted the integrated sustainable waste management approach to manage MSW in the city. The practice however in this city integrates the 3Rs (reduce, reuse and recycle) approaches (Premakumara, Abe & Maeda, 2011:457). In the Integrated process composting is regarded as a technology which can be used in this approach and establishing composting centers within the context was suggested to contribute to the management of waste, Table 4.6 above is indicative of this process. The nature of the sustainable solution to MSW in the city is seen in the ability of the Integrated approach to help reduce waste from the point of generation and to provide suitable WtE ways of managing organic wastes through composting. Non-biodegradable waste is disposed of through reusing and recycling. The result from the use of this integrated method has yielded a relatively good result by helping the city which is the second largest in Indonesia to reduce its waste generation by more than 20% in the past years (Premakumara, *et al*., 2011:457). Additionally, in Table 4.6 above, the Gyanyar municipality in Indonesia has developed the use of waste management technology which centers on segregation and composting of biodegradable organic wastes. This technology is noted to provide a sustainable solution to waste management based on its ability to meet the

following criteria: low cost, low tech, and low-risk approach. The Gianyar composting project has been noted to help in reducing disposable waste by 90%. Almost 60 tons of municipal waste is processed in the project per day from 500, 000 inhabitants (Zurbrügg, Gfrerer, Ashadi, Brenner & Kuper, 2012:2132).

Against the backdrop of the above presentations of different contextual scenarios of the use of WtE technologies in managing waste, it can be concluded that WtE approaches could assist in providing sustainable solutions to waste disposal problems at municipal levels.
The global and regional policy framework stipulates that waste disposal is a global issue. It is as such critical to consider relating global waste management goals and SDG as stipulated in Chapter 2, for purposes of ensuring the importance of proper waste management. The findings centering on the WtE approaches which could provide sustainable solutions to MSW disposal problems could be summarised in the tables that have been tabulated above.

The above presentations of the different WtE approaches/technologies give a clear understanding of the nature of sustainable solutions that some of the identified technologies can provide. The noted positive outcomes from the use of the technologies are also numerous and agree with the conclusion that indeed WtE approaches should be considered as a credible and effective strategy to manage waste at the municipal governance level. However, for this to be realised it is also important to assess the suitability of each technology to a particular context. The findings in literature allude to the centrality of properly assessing and characterizing waste components generated in particular contexts to determine the suitability of using a particular technology in a context.
The above presentations of the different WtE approaches/technologies gives a clear understanding of the nature of sustainable solutions that some of the identified technologies can provide. The noted positive outcomes from the use of the technologies are also numerous and agrees with the conclusion that indeed WtE approaches should be considered as credible and effective strategy to manage waste at the municipal governance level. However, for this to be realised it is also important to assess the suitability of each technology to a particular context. The findings in literature alludes to the centrality of properly assessing and characterising waste components generated in particular contexts in order to determine the suitability of using a particular technology in a context.

4.5 WtE Approaches as Sustainable Solutions to Energy Challenges

The use of the WtE approach to managing MSW from one perspective needs to ideally lead to the generation of renewable energy to solve the energy challenges of many municipalities. Ouda & Raza (2014:270) agree that WtE can assist in the global energy challenge and is a

critical option to handle the MSW disposal challenges. Against this backdrop, it is necessary to look at different scenarios in which WtE approaches have been used to solve the energy challenges of municipalities. This is to further assess how WtE approaches could help solve the energy challenges in the context of the case context that is the Msunduzi Municipality. Notably, views expressed in available literature show that the WtE approaches are envisaged to help and have also led to the successful management of waste and the production of related required energy needs for many cities. From a global perspective, Vaish, *et al.* (2016:324) noted that 'energy security and mitigating its contribution to climate change are two vital challenges experienced by energy sectors to provide a sustainable future.' There is a projection that energy needs in the form of heat and electricity in many urban municipalities of the world will increase by the year 2100 (Vaish *et al.*, 2016:334). WtE approach is considered a sustainable solution to these two problems which are worsening as a result of urban development and migration. Different WtE methods have helped in resolving this problem in many municipalities. The WtE approaches are sustainable as they are cost-effective and environmentally friendly.

Focusing on examples where it has been tried, Jain (2015:408) and Kumar *et al.* (2016:1) note that WtE methods have provided better alternatives to existing unsustainable MSW disposal strategies in different cities in India. The methods have notably helped in solving a dual problem of managing wastes and providing energy for the cities. Jain (2015:406) observed that India has the challenge of producing enough electricity to meet the demands of its ever-increasing population. WtE plants are noted to be sustainable as they are efficient and have the prospects to generate about 1457 Mw of electricity for the country. It is noted that it is thus sustainable as it helps produce clean, reliable energy and the reduction of fossil fuel usage. Also, Kumar *et al.* (2017:8) are of the view that utilizing different WtE approaches could help in not only managing the waste disposal problem in India but in the production of renewable energy needed in many municipalities in that country. The sustainable solution to energy problems in India involves generating hygienic, consistent energy from a renewable fuel source. This will reduce dependence on fossil fuel usage and reducing emissions that are unhealthy, as indicated in Table 4.7 below. Additionally, utilizing WtE approaches to producing sustainable solutions to the energy needs in the municipalities also 'would have significant social and economic benefits for India' (Kumar *et al.*, 2017:8).

Table 4.7: Energy Challenges and solutions in Asia and Europe

Jurisdiction	**Energy challenge**	**Sustainable solution**	**Outcome**
Asia			
India: New Delhi, Indore, Jabalpur	Energy dependent on Fossil fuels (Kumar *et al*, 2017:8)	Hygienic consistence energy	Produce clean & reliable energy
Europe			
Poland	Energy interruptions (Cyranka & Jurczyk, 2016:23	Reliable energy provisions	Simple and efficient

Source: Researcher's data analysis

The illustration in Table 4.7 above shows energy challenges and solutions in selected Asian and European countries.

Using the context of Poland, the possibilities and benefits of adopting WtE approaches for energy recovery were assessed. Cyranka & Jurczyk (2016:23) noted that the modern development of the Polish WtE infrastructure can be a very important factor in influencing the national municipal waste management, Table 4.7 has illustrated. This influence assists in developing renewable energy and energy efficiency policies. An assessment of the moving grate WtE system was made to determine how it could be beneficial to recover energy in the form of electricity. It is observed that the WtE incineration boilers are sustainable because the technology is simple, reliable and efficient in managing waste and generating energy (Cyranka & Jurczyk, 2016:30). The approach leads to energy efficiency and a positive impact on the environment. Similarly, New Zealand is reported to have adopted different WtE technologies to solve the country's energy needs. An analysis of the use of different WtE methods in New Zealand (as shown in Table 4.8 below), reveals that the methods are sustainable as they are environmentally friendly and help reduce the dependence on fossil fuel by the country (Perrot & Subiantoro, 2018:7). The methods also have the potential of producing a sizeable amount of energy per year from MSW.

Table 4.8: Energy challenges and solutions in Oceania and Asia

Jurisdiction	**Energy challenges**	**Sustainable solution**	**Outcome**
Oceania			
New Zealand	Shortage of Energy Dependent on fossil fuel (Perrot & Subiantoro, 2018:7)	Environmentally friendly. It offers air pollution that is within the norm. It is also cost effective, this is an important factor in New Zealand municipalities.	Reduction of fossil fuel use
Asia			
Iran: Chabahar, Kish & Salafchegan	Need an alternative source of energy Government a missing link. Energy is dependent on oil (Madvar, *et al*., 2018:449)	Main source of energy is crude oil that emits unhealthy emissions. The alternative will reduce unhealthy emissions. There is an estimation of creating 55 050 jobs.	Improved energy security. Government to be actively involved in the process
Pakistan: Lahore municipality has nine towns	Severe energy crisis (Shahzad, *et al*., 2017:2728)	Meet the shortfall experienced in energy. MSW is identified as the financially reasonable source of energy.	Environmentally friendly

Source: Researcher's data analysis

The table above illustrated energy challenges with their solutions.

According to Rafati *et al.,* (2016:1) 'one of the most important necessities of life is increasing consumption of energy and its supply for survival and continuation of life.' The authors note that WtE technologies well considered in terms of suitability and functionality could be crucial for addressing Iran's energy challenges. Iran has an abundance of natural gas and the municipalities in the country make great use of this energy (Madvar, Nazari, Arjmand, Aslani, Ghasempour & Ahmad, 2018: 440). But the increasing population has resulted in depleting of this natural resource and there is a need to find alternative solutions, Table 8 above notes this issue. It is suggested that WtE methods are appropriate and offer a sustainable solution to the energy needs of the country. Similarly, Shahzard, Butt, Anwar, Ahmad, Sarwar & Asghar (2017:2728) report that Pakistan faces a severe energy crisis (Table 4.8, above), with the demand for electricity in the country currently standing at 'about 21,200 MW against the maximum generation 16,000 MW, with a shortfall of about 5,000

MW' (Shahzad, *et al*., 2017: 2721). Focusing on the assessment in the Lahore municipality of the country, WtE thermal treatment technology is found to have the potential of solving the energy problem in the country. The solution is sustainable as it provides an environmentally friendly source of renewable energy in the Lahore municipality. About 10,000 kWh of electricity per tonne of MSW could be produced from such a WtE approach for the municipality. A suggestion has been made for the government to utilize the Lahore MSW to fill the energy gap of the country and make its environment pollution free (Shahzard *et al.*, 2017:2727).

Nigeria faces a shortage of electricity which constitutes a great energy challenge for the country. It is the case that the country's population is ever increasing with the reality of rural-urban migration, which has caused greater demands for electricity for these urban areas. Amber, Kulla, and Gukop (2012:47) focus on Nigeria's electricity challenges noting that the use of the WtE incineration plant has the capacity of helping the country generate about 700 KW/day (Kilowatts) of power from MSW. Also, Akhator, Obanor, and Ezemonye (2016:635) examined the use of WtE approaches to solve this energy challenge in Nigeria, as illustrated in Table 4.9 below. It is noted that the use of WtE methods as obtained in Sweden could help Nigeria manage its electricity problem. It is concluded that with the available 14 million tonnes of burnable waste available in Nigeria, this can generate about 4.4TWh (Terawatt/hour) of electricity using WtE technologies (Akhator, Obanor, and Ezemonye, 2016:635). WtE approaches used to generate electricity for the country is sustainable as it is eco-friendly and leads to the country being less reliant on fossil fuels for its energy needs. Still, within the context of West Africa, it is noted that there are electricity challenges in Ghana that result in power outages for the country and there was a need to assess the viability of WtE approaches to solve this problem. There are 254 districts in Ghana, for purposes of the dissertation they have been collated into 5 metropolitan assemblies. These are Kumasi metropolitan assembly, Accra metropolitan assembly, Cape Coast metropolitan, Sekondipro-Takoradu metropolitan assembly, and Tema metropolitan assembly (Abalo, Peprah, Nyonyo, Ampomah-Sarpong & Agyomang-Duah, 2018:2). The finding in Ghanaian municipalities is that waste is an energy generator and income provider that protects raw materials (Ofori, 2016:33). WtE approaches suggested for the municipalities in Ghana are sustainable as they are noted to be environmentally friendly and less dependent on natural gas (Ofori, 2015:1). Furthermore, the use of WtE approaches will have the outcome of producing electricity that can cover twice the annual electricity consumption of Ghana's industrial sector. This is depicted in Table 4.9 below.

Table 4.9: Energy challenges and solutions in Africa

Jurisdiction	**Energy Challenges**	**Sustainable solution**	**Outcome**
Africa			
Nigeria: Lagos, Karo, Ibadan	Shortage of electricity (Akhator *et al*:2016:635)	Incineration	Environmental concerns, need to put pollution control in place.
Ghana	Power outages (Ofori, 2016:1)	Valorization	Produce twice the annual amount
Johannesburg, South Africa	Electricity outages (Matheri, *et al*., 2016:5)	Biological & Thermal	Provision of much needed energy. Still on planning phase
Potchefstroom, South Africa	Electricity Outages (Maisriri, 2016: ii)	Biological & Thermal,	Will produce green energy. Still on planning stage

Source: Researcher's data analysis.

The table above shows energy challenges, solutions and outcomes in Africa as a continent. Additionally, views expressed in extant literature also show that some cities in South Africa are considering and utilizing WtE methods to solve energy challenges. The use of WtE approaches for renewable energy production in the form of biofuel and electricity was assessed focusing on the city of Johannesburg in South Africa. According to Matheri, Mbohwa, Belaid, Seodigeng, Ngila, Muzenda, (2016:5) WtE approaches provide sustainable ways of solving the energy needs in the city. This also provides a key and economically viable component to renewable (green) energy. The transport sector can also benefit from these initiatives. About 750kWh of electricity is noted to be generated from 1Mg (Mill gram) of MSW and this is beneficial for the city of Johannesburg. Similarly, the city of Potchefstroom in the North West of South Africa is noted to have the same energy challenge as experienced in South Africa in the form of a shortage of electricity. On this Maisiri (2016: ii) noted that there is wasted energy in South African city landfills that could be used in WtE thermal technologies. WtE grate incineration technology assessed for the case study municipality is noted to yield approximately 1255 Mw (Megawatts) of energy. The method is sustainable as it helps in reducing MSW thereby enabling a cleaner environment and also generate low-cost energy for the municipality.

In summary, it can be concluded from the above presentation that WtE approaches are capable of addressing energy challenges at the municipal governance level. The hitherto exploration of this theme is summarised in table 4.9 above.

4.6 Energy challenges and Sustainable Solutions

Global perspective (major cities in the world) agrees that general energy challenges experienced in the cities and municipalities are as a result of migration and rapid urbanization (Chee, 2018:1). WtE approaches provide alternative forms of energy to supplement traditional sources of energy in these cities. WtE plants provide cost-effective and environmentally friendly energy. Production of renewable energy (for example high levels of heat, electricity, fuels) is generated from rising amounts of MSW.

It is clear from the above presentations of the different instances of the use of WtE methods to solve energy challenges that different jurisdiction adopts the strategy of combining different WtE approaches. Further in Table 4.10, below another combination of different technologies and approaches will be illustrated. In Sweden for an example the combination provides them with none reliance of foreign energy source and provides them with eco-friendly results (Akhator, et al., 2016:637). The government is also recognizing the combination and provides imcentives for such efforts. The combination results in ensuring that there is no waste that is a left over (Soni, et al., 2016:125). This creates an environment of looking at waste as a source of energy. It becomes important to ensure that proper collection, seperation and transportation is carried out (Soni, et al., 2016:125). This agrees with the IWM framework which substantiates that adopting and integrating different WtE approaches in solving energy problems, is beneficial. In this, the different aspects of WtE are used to manage waste sustainably and at the same time generate different forms of renewable energy. Thus, considered from an IWM perspective, using the WtE method could be and is a sustainable approach to solving the energy needs of different municipalities globally. Conclusively, from the foregoing analysis, WtE promises to be an effective and sustainable solution to the energy challenges at the municipal governance level. However, for municipalities to adopt WtE approaches for their waste disposal problem and energy needs, it is important to delve deeper into explicating and understanding available WtE technologies. This is the focus of the next section and the intention is to understand these technologies to determine their feasibility in the chosen context of this research which is the Msunduzi municipality of South Africa.

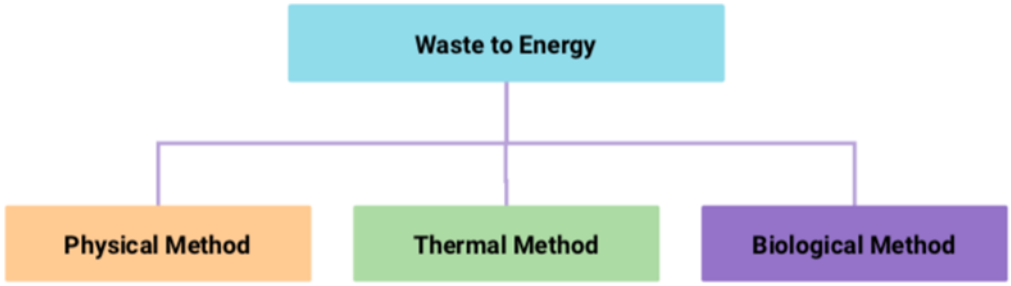
4.7 Available Waste-To-Energy Technologies and Key Components

The rising problem of MSW in many major cities and municipalities of the world resulted in WtE technologies to be developed. This is to manage the disposal of MSW and transforming them into energy resources. That the cities and municipalities can also use. As can be deduced from the previous discussions, different scholars have looked at the WtE innovations and discussed them in detail, focusing on the utility of these technologies to

solving waste disposal and energy problems at the municipal governance level. Summarily, there are three main WtE technological approaches and they include Physical Methods, Thermal Methods and Biological Methods (Mwangomo, 2018:4, Pandey *et al.,* 2016:41; Rafati *et al.,* 2016:176; World Bank, 1999:19).

The diagram below (Figure 4.8) shows the technologies and the approaches will be discussed in detail below:

Figure 4.8: Schematic Diagram of WtE technologies



Source Rafati *et al*. (2016:176).

Table 4.10: Technologies and approaches

Countries	**Waste to Energy Technologies**		**Approaches**
	Biological Methods	Thermal Methods	
Sweden	(Akhator *et al*: 2016:639)	Akhator *et al*:2016:639)	Landfill
			3Rs
			Combustion
			Incineration
			Composting
India	(Soni, et al., 2016:19)	(Municipal Cooperation, 2015:125)	Composting
			Fermentation
			Landfill
Ghana	(Ofori,2015:1)	(Ofori, 2015:1	Anaerobic Indigestion
			Biogas
Nigeria	(Akhator et al: 2016:639)	(Akhator *et al*: 2016:639)	Landfill
			3Rs
			Combustion
			Incineration
			Composting

Source: Researcher's data analysis

Table 4.10 above depicts countries and the WtE technologies with approaches used.

4.7.1 Biological Methods

Biological WtE methods also known as biochemical methods utilize biological components of MSW and transform it into energy in the form of electricity, heat and some fuels used in the transportation sector. Pandey *et al.* (2016:41) affirm that biological action is a technology that uses microbes to produce fuel from waste. Using this method means that waste is treated by a microorganism which breaks down the material in the absence of oxygen (Rafati *et al.* 2016:177). In the WtE biological approach, biological materials are products of metabolic actions of living creatures used as fuel due to their high thermal values. There are three main WtE technologies categorized under the biological methods and they include Fermentation, Landfill and Anaerobic digestion (Rafati *et al.,* 2016; Mwangomo, 2018:4).

a) Anaerobic Digestion

Anaerobic digestion MSW biomass is putrefied anaerobically through the use of bacteria. Pietro & Subiantoro (2018:6) affirm that 'anaerobic digestion is a process involving the decaying of putrescible materials by bacteria acting in the absence of air. Through anaerobic digestion biomass is used to produce a different mixture of gases called Biogas. Biogas has a thermal value of 15-25 MJ per cubic meter from which 1.5-2.2 kWh of electricity can be obtained. Biogas consist of Methane (55-70%) and Carbon Dioxide (CO2) produced after 2-3 weeks after being placed in a digester' (Mwangomo, 2018:5). (Pandey, *et al*., 2016:41) notes that, many applications use Biogas, including stoves and boilers with little modification. For applications in combustion engines (generators, motor car engines).' Hence, anaerobic digestion is an important WtE technology as it is used as a source of renewable energy (Stafford *et al.,* 2013:19**;** Pandey *et al.,* 2016:42). Moreover, this WtE method has many advantages including its ability to lower emissions which is the reason this technology is preferred to incineration of waste (Petro & Subiantoro, 2018:6). However, the technology is noted to be a slow process which constitutes a limitation, which means that this technology cannot be solely relied upon for MSW disposal in a context (Petro & Subiantoro, 2018:6).

In sum, the WtE biological methods are also noted to have helped in solving the waste disposal problems and energy challenges in many municipalities and countries of the world. The biological methods are crucial for cities and municipalities that have an integrated WtE system like Pune Municipality in India, some municipalities in Thailand, Surabaya City and Gyanyar municipality in Indonesia. Used as part of the integrated system, biological methods are suitable for and provide alternative ways of managing biodegradable forms of MSW.

b) Fermentation

This is a process in which bacteria and yeast are used to transform biomass waste to fluid ethanol, acids and other gases in the absence of oxygen (Mwangomo, 2018:5). This method is noted to be used in the transformation of both industrial and domestic waste to produce fuel. Pandey *et al.* (2016:42) describe fermentation as where sugar is changed into acids, gases, and alcohol where yeast and bacteria are present. This is done in a metabolic process. The fermentation method is recommended for managing industrial wastes.

c) Landfill

This an approach of disposing MSW in dug-out pits and harnessing some gases like methane used to generate electricity. Mwangomo (2018:5) explains that 'in landfilling the following process occurs, biological, chemical and physical where waste is composed into leachate and gas. The gas produced consists mainly of Methane, Carbon Dioxide, Water and different traceable materials such as Ammonia Sulphide (H2S) and volatile organic compounds. Utilizing this method helps improve the method of using landfills as just dumping sites for MSW. Through this process gas which may pollute the environment are harnessed for positive purposes. However, this method still has a constraint which is the issue of scarcity of land to site landfills and hence the consideration of this method will depend on the available land.

4.7.2 Physical Methods

Physical methods in waste-to-energy technology involve mechanically working on waste to produce some form of energy production. According to Mwangomo (2018:3) this physical method of converting waste to energy yields compressed fuel product called Refuse Derived Fuel (RDF), it is produced by either mincing solid waste or treating it with steam pressure in an autoclave. RDF composed largely of organic materials taken from solid waste streams such as plastics and biodegradable waste.' It is noted also that 'combusting RDF is a cleaner method than incinerating MSW or other waste directly' (Mwangomo, 2018:5). This is to say that the physical method of WtE could provide a preferable alternative to the reality in which MSW is burnt at the landfills. The method is also noted to produce environmentally friendly alternative sources for feedstock needed to power plants which normally runs with coals (Rafati *et al.*, 2016:175; Mwangomo, 2018:5). Mwangomo (2018:5) further presents the steps used in this WtE technique.

The main steps involved during RDF are categorization, casting or crushing, aeriation, size reduction and formation (Ouda & Raza, 2014:270). RDF particles are mixed with binders such as Calcium Hydroxide. Calcium Oxide (CaO) is added to the refuse dung RDF production. CaO reacts with water to become Ca(OH)2. When flue gas is used as

drying gas Ca(OH)2 and is reacted with CO2 to be CaCO3 then it is converted into pellets in a required shape.

Pandey *et al.* (2016:46) agree that the physical method of WtE involves a mechanical aspect of converting MSW into energy in the form of suitable and durable fuel for further processing. An example of energy product derived from the physical method of WtE is 'are pellets, wood chips, and wood briquettes' and it is noted that further physical recycling can yield a raised energy continent which can be used to generate electricity (Pandey *et al.*, 2016:46). It can be inferred from these views that the physical method in WtE can provide a great way of managing MSW in cities where the rise of plastic and other biodegradable wastes are prominent. The physical process helps to deal with these forms of waste and as can also be taken from the above, fuel products which can help in boosting the energy needs of a city can be derived and this includes electricity. Considering the advantages of this key WtE technology, it is recommended in many African urban cities/municipalities (Mwangomo, 2018:3).

4.7.3 Thermal Methods

The thermal WtE method involves the use of heat applied to MSW products to generate energy. As can be garnered from some studies (Mwangomo, 2018:5; Moya *et al.*, 2017:287); Rafati *et al.*, 2016:175) also the application of some gases to produce energy in the form of heat. Processes in the WtE method are prominent and used in many municipalities and cities of the world including pyrolysis, gasification, combustion, and incineration.

a) Combustion

According to Rafati *et al.* (2016:180), 'Combustion technology has been applied since 100 years ago as a suitable technology to produce energy from urban waste materials.' The system uses what is called mass burners to convert waste into reusable energy. Pandey *et al.* (2016:41) refer to this WtE thermal method as "direct combustion" and describe the process as a method where waste is dried and burns to produce heat directly. The heat generated from the combustion of solid waste is used to change water into steam that utilized in a steam turbine for power generation.' For Mutezo (2015:46) combustion is a WtE thermal technique commonly used to convert biomass waste to electricity in which 'fairly low moisture organic waste is combusted in a furnace or boiler under high pressure.' It is noted that the process requires a pre-treatment of the MSW product and drying it to remove excess moisture. After this preliminary process, the waste is then fed into the mass burners/combustion chambers. The combustion method is used to generate electricity and in some instances steam from waste which makes it a very desirable WtE method (Mutezo, 2015:90). However, it is noted that the combustion process of mass burning can be costly

as it requires higher capital to establish and has notable low conversion efficacy (Akujieze and Idehai, 2014:3).

b) Gasification

Moya *et al.* (2017:289) understand Gasification as a bioprocess in which fuel gas produced through partial oxidation of MSW and can reduce waste mass by 70% to over 90%. Pandey *et al.* (2016:46) further explain that: Thermal gasification is a process that converts an organic or fossil fuel-based hydrocarbon material into carbon monoxide, hydrogen, carbon dioxide at a temperature greater than 700 degrees Celsius with a limited amount of oxygen supply without combustion (Baldino, *et al*., 2019:7). The subsequent gas mixer is called syngas or synthesis gas, or producer gas and it is used as fuel itself for power generation (Pandey, *et al*., 2016:41)

Gasification is a WtE thermal method that has been noted to be a practical viable WtE option and helps in addressing two main waste disposal management dilemmas, which are on how to reduce greenhouse emissions and landfills. Furthermore, according to Moya *et al.* (2017:289) the main advantages of WtE are: decrease of organic impurities; lessening of mass and volume of waste (80% and 90% respectively) (Moya, Aldas, Lopez, & Kaparajo, 2017:290). Also, a high possibility of saving of land; use of recyclables; minimization of emissions and environmental burdens. environmentally compatible with co-generation (heat and electricity production) as a renewable resource of waste; technical and economic feasibility; and it has a high range of working temperatures (700-900°C).

Against the backdrop of the above presentation, it can be concluded that thermal gasification offers a great method to deal with rising MSW in many urban contexts. The crucial aspect of this method which is interesting for the current study is the ability of the gasification method to help in the realization of a healthy and safe environment through its ability to reduce greenhouse emissions and the use of landfills.

c) Incineration

The thermal incineration WtE method is related to the combustion technology and in some literature (for example Moya *et al.*, 2017:289) there is a notable blurring of the distinction between the two. According to Vaish *et al.*, (2016:334) this method involves a 'direct thermal treatment of waste at a very high temperature around 850 °C for recovering energy in sufficient quantity of oxygen to oxidize the fuel.' For Mwangomo (2018:5) incineration is a method that combines heating of waste in the presence of air at a high temperature of 850°C. This then converts waste into Carbon Dioxide, Water and Non- Combustible materials with solid residue (bottom ash). From the above descriptions, it could be summarily said that incineration is a process of recovering energy from the remains of waste through a process of burning (Ouda & Raza 2014:270; Sun *et al.*, 2018: 290). This

is achieved through the use of an Incinerator which is a strong and well-insulated facility (to prevent heat loss) used to burn waste to ashes in a fast and efficient manner and releasing heat (Mwangomo, 2018:5).

Summarily, the WtE thermal methods have become a crucial WtE approach widely used in many countries and municipalities of the world. As already discussed in the previous section, many municipalities and countries (India, Poland, Chile, United States of America, Pakistan, Nigeria, Ghana, Johannesburg and Potchefstroom in South Africa) have used the different components of the thermal methods. This WtE thermal method has helped in the need for electricity generation, improving fuel diversification and reducing the amount of MSW directed to landfill sites (Ofori, 2016:11; Vaish *et al.,* 2016:332). Incineration is regarded as an old, mature technology that has been used in various countries. Notably, recent improvements and advancements to this WtE technology have seen the integration of air pollution control mechanisms crucial in realizing a clean aerated environment (Mwangomo, 2018:5).

d) Pyrolysis

Pyrolysis involves the processing of waste and its conversion into different energy products. (Mwangomo, 2018:4) describes Pyrolysis as; where waste is arranged and shredded to reduce its size and is placed into a reactor that has no oxygen. A specific temperature required to continue with the process. The products of pyrolysis process are solid char, oily liquids gases such as hydrogen (H2), Carbon Dioxide (CO2) and Volatile Hydrocarbons such as Methane (CH4) (Mwangomo, 2018:4)

Pyrolysis is understood as a thermo-chemical WtE approach in which the temperature of collected MSW is increased without the presence of oxygen. This process, in turn, yields combustible gas, liquid, and solid deposits. Rafati *et al.* (2016:46) further explains that;

> Pyrolysis involves the concurrent change of chemical composition and the physical phase and is permanent in nature. The products from pyrolysis are such as methane, hydrogen, hydrocarbon, charcoal, vinyl chloride, cock, and carbon monoxide used further for power generation in power cycle operation.

Summarily, Pyrolysis is an advanced thermal treatment technology used to burn waste at high temperatures to produce energy. It is noted to be advantageous as it can control emissions to required levels (Jourhara, *et al.*, 2018:118). Also, the advantage of the technology is that it reduces waste volumes by 80% to 90 % and the mass between 70% and 80% (Chhabra, Shastri and Bhattachrya, 2016:514). This process also decomposes MSW materials that could have taken several years to decompose in minutes or hours. However, there are undesirable by-products that come out of the process that needs to be

treated, which at times may increase the cost of the technology. Hence Mwangomo (2018:4) notes that according to available literature 'pyrolysis has not been a successful method of converting waste into energy since its main product is carbon monoxide (CO).'

4.8 WtE technologies that could be utilized in Msunduzi Municipality

This section is summarized under the theme of available WtE technologies and key components. The focus is on addressing the third objective of this study that is to ascertain what waste-to-energy technologies and key components are available and utilised in the context of the study. From the above presentation, one can deduce that there are indeed several innovations in the WtE sector. These innovations could be Msunduzi municipality's efforts to manage its waste sustainably while producing energy that is used for the energy needs of the municipality is critical. The available technologies as noted here include the physical, thermal and biological methods. From the presentation and discussions, it is also obvious that the different major methods and their components WtE technologies have various advantages and disadvantages. These positive and negative factors may come in handy in the consideration of the use of any of these technologies for the Msunduzi municipality.

Since this study has adopted the IWM framework and considering the legislative and policy requirement existing in South Africa, this study proposes that the WtE component that could work in the Msunduzi municipality should comprise of the different aspects and key components of the WtE approaches. As already, discussed Pune Municipality in India and some municipalities in Thailand, Surabaya City and Gyanyar municipality in Indonesia, provide clear examples in which the integrated model has been used. Proposing this model for the Msunduzi municipality will be informed by the fact that the available WtE technologies have key components that if used in tandem, could help address different aspects of the MSW generated in the city.

The effort will be on how to integrate aspects of the available technologies, harnessing the positive aspects and key components and using them wherever suitable in managing MSW in the Msunduzi municipality. The choice of WtE key component adopted at the Msunduzi municipality governance level should depend on various factors. The level of maturity of the municipality's waste management sector; feedstock type or the type of waste and its features. The geographical factors including availability of land; availability of funds to procure such technologies; availability of skilled personnel; the efficiency of the selected technology and social acceptability (Ouda & Raza, 2014:273; Mutezo 2015:79; Malinauskaite *et al.*, 2017:2014). Assessing these as it concerns the Msunduzi Municipality will be part of the content of the next major section that explores available lessons from other jurisdictions regarding the adoption of the waste-to-energy technologies that may

benefit Msunduzi municipality. Table 4.11 below is illustrative of the different approaches and similarities to the Msunduzi municipality.

Table 4.11: WtE Technologies and Key Components

WtE technology key components	**Difference between the approaches**	**Similarity of the jurisdiction to Msunduzi**	**Jurisdiction**
Physical Method: 1. Refuse Derived Fuel	Mechanically working on waste to produce an energy product. The end product is called Refuse Derived Fuel (RDF)	The municipality as part of its waste has, garden waste, that will be shredded to form manure. As part of the WtE process, there is a process of conducting a feasibility on mining already compacted waste in the landfill.	United States of America, Lee County, Florida, Sheffield in the United Kingdom. Porto in Portugal, Asia.
Thermal Method: 1. Pyrolysis 2. Gasification 3. Combustion 4. Incineration	Use of heat to radiate energy. It has various components that are listed in the first column. Countries use one or a combination of the components	The feasibility study that was conducted is suggesting the three methods as indicated in the first column. These methods are envisaged to be workable in the municipality.	Pune Municipality in India, municipalities in Thailand, Surabaya City and Gyanyar municipality in Indonesia
Biological Method: 1. Fermentation 2. Landfill 3. Anaerobic Digestion	These are biological methods that are used to convert WtE. This process makes use of microbes. Fermentation is a process that is used in the absence of oxygen. Landfill is compacting of waste and develop a system of containing leachate that is coming out of the compacted waste. Presence of oxygen in the not well compacted waste may course fire that is highly toxic. Anaerobic Digestion, is a process where waste is treated in the absence of air and forms biomass that becomes fuel.	Currently the municipality is using the Landfill method that is a challenge. The currently used site is quickly reaching its end of life. The municipality is looking at ways of providing a service that will also assist with electricity challenges.	India, Taiwan, Poland, New York, Japan, USA, Europe, London, Amsterdam. Austria, France, Netherlands, Sweden, China

Source: Researcher's data analysis

Table 11 above depicts municipalities that have similarities to Msunduzi municipality and the technologies that have been implemented. Below is a summary of Chapter 4.

4.9 Summary of the Chapter

This Chapter gave a presentation of the findings and discussions in the study. The aim is looking at WtE as an alternative approach to waste disposal in Msunduzi municipality, South Africa. The Chapter concentrated on secondary data that views sustainable solutions to MSW problems and how WtE technologies can provide such. It secondly focused on how WtE approaches provide solutions at the governance level. It also provided a discussion on the available WtE technologies across continental jurisdictions that could be used in the Msunduzi municipality. A final look at the lessons that the municipality can learn in the jurisdictions was also described. The guiding principles used are the objectives and the research questions.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This Chapter is set to out to present the dissertation findings, policy implications, recommendations, and conclusions hereto. The paper assesses the feasibility of WtE in the Msunduzi municipality. A set of four questions and four objectives as part of a response to the research problem. A summary of Chapters in response to the questions is highlighted below.

5.2 Research Questions and Objectives

The table below presents the questions and objectives of the research problem. They look at various aspects that include, WtE technologies, approaches, energy challenges and sustainable solutions

Table 5.12: Questions and Objectives

Questions	Objectives
How can WtE approaches provide sustainable solutions to the waste disposal problems at municipal governance level?	Determine whether or not WtE approaches could assist in providing sustainable solutions to waste disposal at municipal governance level;
How can WtE approaches provide sustainable solutions to energy challenges in at municipal governance level?	Discover whether or not WtE can assist with providing sustainable solutions to the energy challenges at municipal governance level;
What notable WtE technologies and key components (if any) are available to solve the waste and energy challenges in Msunduzi municipality?	Ascertain what available WtE technologies and key components (if any) can be utilised in Msunduzi municipality
What lessons can Msunduzi municipality learn from other jurisdictions regarding adoption of waste-to energy technologies?	Explore available lessons from other jurisdictions regarding adoption of the WtE technologies that may benefit Msunduzi municipality.

The Table above tabulates the questions and objectives. Below is an effort at a presentation of the summary of Chapters in their response to dissertation questions. A summary of how each Chapter responded to the research question will be conferred.

5.3 Summary of Chapters

5.3.1 Chapter One

The Chapter introduced the dissertation. It contributed to the dissertation by stating the research problem from which the research questions and objectives were drawn. The Chapter laid the foundation for the methodological approach and perceived significance of the study.

5.3.2 Chapter Two

Literature that provided the basis for the researcher to be in a position to respond to the questions is elaborated on in Chapter 2. The background on getting tangible information and understanding of the legislative framework, concepts are encapsulated in the Chapter. The literature in the Chapter provided information on WtE approaches that can offer sustainable solutions to waste disposal in Msunduzi municipality. The approaches included amongst others, valorisation which is a combination of composting and anaerobic indigestion, incineration, gasification, combustion, and pyrolysis. Municipalities that have used these approaches as means of disposing MSW are Ghana (valorisation), Pune municipality in India (composting, bio methanation & fermentation). The latter responds to the second question.

Document analysis on documentation that is considering WtE approaches that are sustainable solutions to energy challenges was tabled in this Chapter. India is generating about 1457 megawatts of electricity from MSW. In Poland, incineration boilers produce clean, reliable energy and reduce fossil fuel. This expounds responses to the second question.

As a Chapter that is focused on literature, all the questions that were probed were responded to. The third question looked at WtE technologies that can assist the municipality to deal with the energy challenge. Literature thus, providing three technologies being Biological Method, Physical and Thermal Method. Each of these technologies has various approaches that can be used. Lahore municipality in Pakistan has severe energy challenges. They use thermal technology to produce much-needed energy.

The last question was considering interrogating lessons that Msunduzi municipality can learn from other municipalities. The literature provided information on these lessons, like for instance, Surabaya City in Indonesia, uses WtE technologies to solve both their MSW challenge and shortage of energy. They have implemented some compositing centres in the city. Non-biodegradable waste is disposed of through a process of reusing and recycling. This reduces their waste by 20%. In the United States, Thermal methods are used by municipalities, and these are incineration, gasification, combustion, and pyrolysis.

5.3.3 Chapter Three

For purposes of the researcher to be in a position to methodologically respond to the questions that emanate from the research problem, this Chapter was critical in creating such a platform. This Chapter provided a vehicle and a plan for the flow of the dissertation by demonstrating the methods undertaken to answer the research questions and achieve the research objectives.

5.3.4 Chapter Four

Chapter four discussed data presentation, analysis, and presented findings. In this Chapter, all research questions were addressed through tables and narratives that analysed the secondary data within the tables. In other words, this Chapter illustrated the findings which help address the research problem. It supplied the data a tool to aid in decision-making on WtE technology, capacity issues and financial considerations. This was designed to provide guidance to South African municipalities in search of sustainable solutions to waste disposal and energy challenges as well as consideration of WtE technologies for generating sustainable solutions.

5.3.5 Chapter Five

In this Chapter the objectives of the exposition were tabled. Section 5.4 of this Chapter shows the findings, conclusions and recommendations discerned with respect to each research objective. Since the research questions mirror the research objectives, this Chapter clarifies how the research questions were answered. This Chapter then goes on to highlight the contribution

5.4 Objective 1

Determine whether or not waste-to-energy approaches could assist in providing sustainable solutions to waste disposal at Msunduzi municipal.

5.4.1 Findings

After a presentation of different context examples of successful WtE approaches, the findings are that WtE can provide a sustainable solution to waste disposal at Msunduzi municipality. The approaches that are described in the dissertation are, fermentation, landfill, anaerobic digestion, gasification, combustion, RDF, incineration, pyrolysis, and valorisation. A combination of anaerobic indigestion and composting (valorisation) have been central in sustainably solving waste disposal challenge in Ghana. A study conducted in Ghana finds that the landfill is not sustainable in that it is a health hazard both to humans and the ecosystem. Also that waste is an income source and it can generate energy.

The various municipalities in New Zealand, use some WtE approaches to deal with waste disposal. The approaches are anaerobic digestion, gasification, incineration, and pyrolysis. The municipalities are Christ church, Regional council of Auckland, Waitakere City, Tampo, and Masterton Davenport. Waste in Christ Church has been reduced by 20% and in Masterton Davenport by 30 to 60%. Anaerobic digestion is environmentally friendly. Recycling is key for the success of WtE approaches in MSW disposal.

5.4.2 Conclusions

The dissertation concludes that WtE approaches can provide a sustainable solution to waste disposal as it has been implemented in various municipalities as argued in the dissertation.

5.4.3 Recommendations

- It is recommended that proper public administration and municipal governance skills are made central to help make the adoption of WTE a success.
- It is recommended that the Msunduzi municipality considers WtE technologies and approaches as means of responding to the landfill site the burns occasionally with toxic fumes.

5.5 Objective 2

Discover whether or not waste-to-energy could assist with providing sustainable solutions to the energy challenges at Msunduzi municipality.

5.5.1 Findings

The municipalities that have been discussed in the dissertation, have shown that the use of WtE provided them with sustainable solutions. In India, there is also a shortage of electricity. The cities of New Delhi, Indore, and Jabalpur amongst others are generating volumes of waste. About 166 million MSW, when treated, generates 600 KW per ton of electricity. The findings are that WtE produces clean energy, it provides an opportunity for recovering material and frees land up for other use. The plant in India is developed under a Build, Operate and Train program (BOT).

In Nigeria, the increase in population and the rural migration created electricity challenges. The incineration plant will generate 700kw/day. 14 million tonnes of burnable waste will generate an amount that will assist in the energy challenge that is being experienced.

Johannesburg in South Africa is also considering biofuel for transportation. This will impact on green energy. Potchefstroom has energy challenges; the use of the thermal method is generating 1255 MW of energy.

5.5.2 Conclusions

After its presentation, analysis, and interpretation the dissertation concludes that WtE is capable of addressing sustainable energy challenges at the municipal governance level.

5.5.3 Recommendations

- It is recommended that to successfully utilized WtE technologies, municipalities need to be adequately financed.
- The provision of training for technical knowledge is critical, through the Build Operate and Transfer programme (BOT).

5.5 Objective 3

Ascertain what available waste-to-energy technologies and key components (if any) could be utilized in Msunduzi municipality

5.5.1 Findings

There are indeed many WtE technologies and key components that have been used by other municipalities. Lahore municipality in Pakistan is using Thermal methods, incineration as an approach. Lahore Waste Management Company (LWMC) is divided into nine towns for MSW collection. MSW generates 7608.69 megawatts, the towns have a shortfall of electricity between 1000 & 5000 megawatts. WtE meets the shortfall experienced

WtE in Nigeria is at an infancy stage. There are various cities, Lagos, Karo, Makurdi, Onitsha, and Ibadan to count a few. The indications are that 90% of waste volume can be reduced by WtE. This would be coming from all these cities and those that have not been included. Incineration as an approach is being considered. It has been noted that it has environmental concerns. These include amongst other pollution. A proper control mechanism needs to be put in place. There is also a lack of proper policies, legislation, waste handling, and awareness to properly support WtE.

Comparing this to Sweden, it is regarded as the WtE success story. They are recovering 3MWH per tonne of solid waste. Their energy recovery capacity from waste is more than the domestic available combustible waste. As such waste is imported. There is government support in policy creation. They prefer waste reduction, reuse, and recycling to energy recovery. They also, prefer energy recovery to landfill.

Msunduzi municipality can use Thermal technology and its components as well.

5.5.2 Conclusions

Msunduzi municipality as discussed in the document is experiencing both waste disposal and energy challenges. As such it is concluded that these technologies can assist the municipality in providing a solution for both.

5.5.3 Recommendations

- It is recommended that WtE technologies are a good concept that needs proper policy support.
- It also recommended that the municipality and waste technocrats get more knowledge on WtE technology for proper implementation.

5.6 Objective 4

Explore available lessons from other jurisdictions regarding the adoption of the waste-to-energy technologies that may benefit Msunduzi municipality.

5.6.1 **Findings**

The global North is providing lessons on the feasibility of the implementation of WtE for both MSW disposal and energy provisions. Some of the lessons are that MSW can be disposed of completely when using WtE to the extent of exporting waste such as the case of Sweden. In Poland, the lesson is that WtE is reliable, simple and efficient. In New Zealand, WtE is environmentally friendly and that recycling is key. The United States of America provides lessons that WtE produces cleaner emissions, reduces waste and there is little landfill site use. These are the lessons from the global North.

Lessons from the global South are mixed. Concerning the lessons from Chile, WtE reduces waste and provides much-needed energy. India, Pune municipality, there is no waste leftovers. Thailand teaches us that WtE technologies used there are providing a sustainable solution to both MSW and energy challenges. Indonesia shares that its waste is reduced by 20%, it is low in cost, low risk and is low in technology. By embarking on WtE technologies to treat its MSW, Iran can benefit from its energy challenges. Pakistan Lahore municipality provides a lesson that their use of Thermal technologies in their WtE processes are meeting their electricity demand. Nigeria is still in infancy stages and critical policies need to be adopted, knowledge on the implementation needs to be transferred. Municipalities in Ghana shared a lesson that waste and energy generation is income for the municipalities. Johannesburg is still in the planning phase. Potchefstroom's thermal technology is producing much-needed energy.

The above lessons shared from the global North and global South are allowing Msunduzi municipality to ponder on them for its implementation.

5.6.2 **Conclusions**

Lessons that have been learned brings one to the conclusion that a technology decision should be based on the benefits that it will bring. This needs to be coupled with financial considerations within the institution. Municipalities in both the global South and Global North have shared lessons in terms of the approach they have taken.

5.6.3 Recommendations

- It is then recommended that the municipality also consider its position and thus make a decision about the type of approach to be used.
- It is recommended that the Msunduzi municipality takes best practice from other municipalities.
- In-depth studies on both these issues need to be further interrogated.

A look at contribution to the body of knowledge is below.

5.7 Contribution to the Body of Knowledge

The dissertation helps contribute to the body of knowledge on sustainable solutions to waste disposal and energy challenges and WtE technologies as they relate to the broader area of public administration and municipal governance. Specifically, this dissertation provides a rigorous review of secondary data to present lessons from other jurisdictions worldwide that may benefit Msunduzi municipality.

Policy-makers need to take into serious consideration the role that policy needs to play in creating a platform that is decision-based.

The view of the dissertation is that a serious and critical policy implication route needs to be considered in relation to WtE approaches. It has been indicated in the study that; these technologies are expensive. A collaboration between government departments to come with a policy structure that will assist an ailing municipality is long overdue when it comes to dealing with WtE related matters.

Training is also a critical component of the success of the implementation of these technologies for purposes of in-house knowledge. Policy development should be tailored in a way that tailored around this critical skill is imperative.

A look at the contribution of knowledge is above and the following section will look at overarching recommendations.

5.8 Overarching Recommendations

Whilst sections 5.4 to 5.6 set forth specific recommendations for each objective, this section provides a broader set of recommendations based on the study as a whole.
It is therefore recommended that:

- WtE technologies be developed and applied to curb the MSW challenge which municipalities face in both global North and Global South countries. The approach that can be used in these jurisdictions depends on the ability and capacity of the municipality at the public administration and municipal governance interface.
- The state to uptake the tools of analysis for effective and efficient public administration to ensure that mandates of the South African Constitution are met as sustainable solutions to waste disposal and renewable energy fall within ambits of the human rights based South African Constitution.
- Municipalities provide procedures and processes of sorting waste before engaging in WtE modalities. This is because the quality of the energy produced is determined by the quality and tonnage of the waste.
- Municipalities explore various innovative ways of upgrading financial capabilities so as to implement WtE technologies. This includes collaboration with the private sector to develop public-private partnerships for MSW management and WtE technological development.
- A collaboration between government departments be undertaken to develop and implement a policy structure to assist any ailing municipality in dealing with WtE related matters in South Africa.
- Training be seen as a critical component of creation and implementation of WtE technologies and actioned accordingly.
- The issues brought forth in this dissertation, including available lessons for South African municipalities be further interrogated through in-depth research studies.

5.9 Policy Implications

As indicated both MSW and energy are a challenge at the municipal level. There are competing functions concerning disposing of waste or building houses and the provision of land for burial purposes. Policymakers need to take into serious consideration the role that policy needs to play in creating a platform that is based on sound decisions by learning from lessons in other jurisdictions. The DEA has created policies dealing with waste disposal and WtE policies. There is a need to create synergy in the working relationship between the Department of Minerals and Energy and the Department of Environmental Affairs to

influence policy making geared towards WtE. This will assist municipalities to make informed policy decisions.

5.10 Summary of the Chapter

The dissertation assessed the feasibility of utilizing WtE technologies, towards a sustainable and integrated waste disposal approach in the Msunduzi Municipality, South Africa. Msunduzi municipality is in the Kwa Zulu Natal province in South Africa. Countries both in the global North and Global South have a challenge with energy resources. The state and local municipalities have a mandate to provide solutions for the challenges. MSW disposal is a challenge due to various factors that have been covered in the dissertation. Available literature in the field of WtE was used and the findings are that it is feasible to use the technology as a solution. Technologies referred to are Biological Methods, Physical Methods and Thermal Methods.

This dissertation will start to help municipal authorities to make proper choices in their efforts at managing recommendations that will open a way to sort the challenge of MSW disposal in a sustainable manner and alternatives to energy. An in-depth work on literature from other jurisdictions and how they approached the challenge at hand formed the bases of the findings, conclusions and recommendations highlighted in this final chapter which concludes the dissertation.

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ANNEXURE ONE: ETHICAL CLEARANCE LETTER

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Miss Boniwe Zulu (921315442)
School Of Man Info Tech &Gov
Westville

Dear Miss Boniwe Zulu,

Protocol reference number: 00001947
Project title: Towards a Sustainable and Integrated Waste Disposal Approach:Exploring Waste-to-Energy Feasibility in Msunduzi Municipality, South Africa

Exemption from Ethics Review

In response to your application received on 19 June 2019, your school has indicated that the protocol has been granted **EXEMPTION FROM ETHICS REVIEW.**

Any alteration/s to the exempted research protocol, e.g., Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through an amendment/modification prior to its implementation. The original exemption number must be cited.

For any changes that could result in potential risk, an ethics application including the proposed amendments must be submitted to the relevant UKZN Research Ethics Committee. The original exemption number must be cited.

In case you have further queries, please quote the above reference number.

PLEASE NOTE:
Research data should be securely stored in the discipline/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours sincerely,

[redacted]

Prof Maria Isabel De Azevedo Martins
Academic Leader Research
School Of Man Info Tech &Gov