TOWARDS A ZERO WASTE SOUTH AFRICA: A CASE STUDY ON POST-CONSUMER SOLID WASTE MANAGEMENT IN RURAL AND URBAN AREAS

by

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ABSTRACT

Through the National Environmental Management Act (No. 107 of 1998), the South African Department of Environmental Affairs and Tourism (DEAT) introduced the concept of the Waste Hierarchy (Reduce – Reuse – Recover – Dispose) as the only possible road towards sustainable development. This concept of sustainable waste management was extended into the Polokwane Declaration on Waste Management which identified Zero Waste as the ultimate goal for sustainable waste management systems in South Africa. Zero Waste is defined as the concept of using all waste produced in a certain area for production activities in that area when it is environmentally acceptable, socially equitable and economically viable, with unavoidable residual waste going to landfill.

The aim of this thesis is to test the applicability of Zero Waste to post-consumer waste arising from rural and urban areas. The primary reason that this study has been attempted is that little research in South Africa has focused on the demand-side management of post-consumer waste, and that whatever research that has been undertaken has focused almost exclusively on waste management in urban areas. In order to realise the aim of this thesis, two case studies were selected and analysed: one rural and one urban. These case studies were selected due to differences in characteristics of the waste arising from households, existing waste management systems and socio-economic indicators for households in these areas.

In each case study, a proposed Zero Waste Scheme was assessed for application based on four sustainability criteria: environmental, social, economical and institutional. The Zero Waste Schemes are based on the conceptual Zero Waste Model (ZWM) that has been specifically developed as the main tool for conducting this research. The development and use of the ZWM in assessing waste management systems in South Africa is a significant contribution of this thesis to knowledge.

Generally, the results showed that the proposed Zero Waste Schemes could meet three of the evaluation criteria used in the investigation, but could not meet the fourth: institutional sustainability. For this reason, the Zero Waste Schemes could not be implemented since the municipalities responsible for waste management in those areas did not have the capacity – administrative, financial resources and political will – to implement them. Thus, institutional sustainability has been shown to be the main constraint in the application of Zero Waste Schemes in post-consumer waste management systems in South Africa. This is another significant contribution of this thesis to knowledge.

Other significant findings from this study reveal that rural areas lack basic waste collection and disposal systems; hence this lack in service delivery prevents full implementation of Zero Waste Schemes in these areas. In contrast, households in urban areas are served by integrated waste management systems that extend to most households, and most of these households are able to finance the waste management services provided. The existence of the integrated waste management systems was used as a basis for introducing waste minimisation and at-source separation of recyclables in order to reduce the amount of waste needing disposal. Education of households in urban areas has been identified as a key factor in establishing Zero Waste Schemes in the case study areas.

In conclusion, it has been shown in this thesis that although Zero Waste Schemes are theoretically applicable to rural and urban areas of South Africa, institutional constraints that will have to be overcome in order to make Zero Waste a reality. Implicit in this conclusion is the extension of waste collection services to rural households and the full participation of rural and urban households in Zero Waste Schemes, participation which can only be verified by actual implementation of the schemes. This is the next step in the approach towards Zero Waste within post-consumer waste management in South Africa.

Dedicated to my mother

‘M`e ‘Mantlibi Khabati Matete

Thank you for your encouragement and support

“*Kea Leboha*”

PREFACE

I, Ntlibi O. Matete, hereby declare that the whole of this thesis is my own work and has not been submitted in part, or in whole to any other University. Where use has been made of the work of others, it is duly acknowledged in the text. This work was carried out at the University of KwaZulu-Natal, Department of Civil Engineering, under the supervision of Prof. Cristina Trois. The style guide for theses in the Faculty of Engineering has been used in the preparation of this document.

Date 20/02/2009 Signature N. Matete

As the candidate's supervisor I have approved this thesis for submission

Signed Cristina Trois

Name PROF. C. TROIS

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LIST OF ABBREVIATIONS

ABEMS	Abongi Bemvelo Environmental Management Services
CBA	Cost Benefit Analysis
CRECHE	Centre for Research in Environmental, Coastal and Hydrological Engineering at University of KwaZulu-Natal
DCEE	Dictionary of Civil and Environmental Engineering
DEAT	Department of Environmental Affairs and Tourism
DoH	Department of Health
DoT	Department of Transport
DSW	Durban Solid Waste
ELCA	End-Life Cycle Assessment
EPR	Extended Producer Responsibility
GD	Government Digest
GDP	Gross Domestic Product
GRRN	Grass Roots Recycling Network
GWP	Global Warming Potential
GHG	Green House Gas Emissions
HDPE	High-Density Polyethylene
IADF	Institutional Analysis and Development Framework
IDP	Integrated Development Plan
IWMP	Integrated Waste Management Plan
LCA	Life Cycle Assessment
LDPE	Low-Density Polyethylene
LSS	Landfill Space Saving
MCDA	Multi-criteria Decision Analysis
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
NEMA	National Environmental Management Act (No. 107 of 1998)
NIMBY	Not in my backyard
NGO	Non-governmental Organisation
NWMS	National Waste Management Strategy
PAYT	Pay as you throw
PEACE	Planning Education Agriculture Community Environment
PET	Polyethylene Terephthalate

PFSA	Plastics Federation of South Africa
RSA	Republic of South Africa
SAIRR	South African Institute of Race Relations
Stats SA	Statistics South Africa
TPB	Theory of Planned Behaviour
TZC	Target Zero Canada
UNDP	United Nations Development Programme
US EPA	United States Environmental Protection Agency
WMS	Waste Management System
WRC	Water Research Commission
ZWM	Zero Waste Model
ZWS	Zero Waste Scheme

If not this way, how?
If not now, when?
(Primo Levi)

CHAPTER 1

1. INTRODUCTION

1.1 Introduction

Modern society faces the pressing challenge of effective and efficient management of the ever growing volumes of municipal solid waste (MSW) being generated in residential areas (Kocasoy, 2000). The MSW that is being generated in residential areas, as depicted in Figure 1.1, is termed post-consumer waste. Although it differs in extent from country to country and region to region, the primary strategy of dealing with MSW is to dispose it in sanitary landfills as shown in Figure 1.2 or non-engineered landfills known as dumps. The siting of these landfills and the landfill degradation products associated with them are significant problems when it comes to managing post-consumer waste.

In terms of landfill biological processes, decomposition of waste in a landfill leads to the generation of carbon dioxide (CO_2) and methane (CH_4) gases. Both of these gases are known to contribute significantly to green house gas (GHG) emissions that are deemed responsible for a phenomenon known as global warming (Takle, 1995). According to the Intergovernmental Panel on Climate Change [IPCC] (1990), CO_2 and CH_4 account for 61% and 15% respectively of the total effects of GHG emissions on global warming. Furthermore Keihl and Trenberth (1997) and Hugo (2004) assert that global warming, also known as the greenhouse effect, leads to ecological and environmental degradation of the planet, and that this will have a significant impact on the global economy. However, IPCC (2004) has shown that the release of CO_2 and CH_4 from landfills accounts for less than 2.8% of GHG emissions. As such, landfill biological processes are less problematic than the siting of landfills in the management of increasing volumes of post-consumer waste.

In this thesis, MSW refers to solid waste arising from a residential dwelling or commercial establishment within a residential area. Both waste streams are collectively defined as post-consumer waste.

Figure 1.1: Municipal Solid Waste arising from a residential area in Durban, South Africa

In terms of landfill siting, the frequent problem encountered is that existing landfills are located within or in close proximity to residential areas. This close proximity poses risks such as contamination of ground and surface water by landfill leachate, undesirable levels of air pollution and loss of property values for residents near the landfills (Okeke and Armour, 2000; Al-Yaqout et al., 2002; Sasao, 2004). These potential risks have given rise to what is generally known as NIMBY syndrome (Not In My Backyard), which is defined as the social rejection of waste management facilities that although deemed necessary, often have a negative social connotation (Pol et al., 2006). Furthermore, a rapid increase in urban sprawl and an increasingly environmentally aware public are putting pressure on waste managers to locate landfills further away from residential areas (Water Research Commission, 1995; Roebuck, 2005). Although this may alleviate or reduce the NIMBY problem, it creates another problem: increased collection and transportation costs that account for about 80% of the total waste management costs (Davies and Cornwell, 1998; Lombard, 2005).

Figure 1.2: Waste disposal in a sanitary landfill (Mariannhill Landfill in Durban, SA)

The problems associated with landfills that have been highlighted in the preceding discussion are a reflection of the waste management systems (WMS) which rely heavily on landfills as the ultimate method for dealing with post-consumer waste. Although these problems are generic for landfills globally, they differ in extent due to the type of WMS from which post-consumer waste arises. These WMS can be broadly divided into systems operational in economically developed countries and those employed in economically developing countries.

In developed countries, landfilling, incineration and recycling are the main strategies of dealing with MSW (Goddard, 1995; Ishizaka and Tanaka, 2003; Husaini et al., 2007). For example, 67% of MSW generated in England is landfilled, while 9% is incinerated and 24% recycled or composted (Husaini et al., 2007). However, due to the problems that are being encountered in the siting of landfills and incinerators through the NIMBY effect, waste management is gradually shifting focus from waste elimination to integrated

Figure 1.3: Bisasar Road Landfill, Durban - SA (the landfill is located on the left of the picture, while a residential area can be seen on the right abutting the boundary of the landfill site)

meet their own needs" [World Commission on Environment and Development (1987) cited in Macris and Geogakellos (2006); Glavic and Lukman (2007); Ness et al. (2007)]. The key criteria for Sustainable Development are: protection of the environment, social development and economic development (Novella, 2007).

With regards to waste management, sustainable development has been encapsulated in Chapter 21 of Agenda 21 which states that "environmentally sound waste management must go beyond safe disposal or recovery of wastes that are generated and seek to address the root cause of the problem by attempting to change unsustainable patterns of production and consumption" (United Nations Division for Sustainable Development, 2007). The research documented in this thesis is an attempt to apply Sustainable Development criteria to post-consumer waste management in South Africa by testing whether it is possible to achieve zero waste in a typical urban area and a typical rural area. These areas are representative of waste management systems that are characteristic of both developed and developing countries.

1.2 Motivation and Objectives

Given its present status as an economically developing country (Borland et al., 2000) and its unique development history, South Africa has a WMS that displays characteristics of both developed and developing countries. As a result, waste management services are inequitable across regions and within communities located in the same municipal area. Middle income and upper income areas have WMS that are similar to those of developed countries, the exception being the degree to which households participate in source reduction of waste and at-source separation of recyclable waste. Conversely, most low income areas, whether informal urban or rural areas, have WMS that are characteristic of developing countries. In these areas, reuse or recycling of waste takes place as a result of monetary benefits associated with such a practice (Borland et. al, 2000; Fiehn, 2007; Liebenberg, 2007).

In order to address the issue of unsustainable waste management systems, the South African Department of Environmental Affairs and Tourism (DEAT) introduced the concept of waste hierarchy (Reduce – Reuse – Recover – Dispose) into environmental legislation (Republic of South Africa, 1998). This legislation was further strengthened through the enactment of the Local Government Municipal Systems Act (Republic of South Africa, 2000). The Act requires that "municipalities strive to ensure that services are provided to local communities in a financially and environmentally sustainable manner, and that local communities have equitable access to such services" (Matete and Trois, 2008). Based on the legislation, progress has been made in addressing many of the environmental issues associated with waste disposal by landfill, but little has actually been achieved in terms of reducing waste generation by involving households (Ball, 2006). The reduction of waste generation is the primary aim of sustainable development in waste management systems according to Agenda 21.

Despite the enactment of legislation and promotion of recycling, post-consumer waste volumes continue to increase since these measures do not target waste generation specifically (Wiechers et al., 2002). In order to address the issue of increasing waste volumes, the Polokwane Declaration on Waste Management was agreed upon between civil society, the business sector and the public sector (DEAT, 2001). The Declaration set as its target the reduction of waste generation and disposal by 50% and 25% respectively by the year 2012 and the development of a plan for zero waste by 2022 (DEAT, 2001).

"Zero waste is a goal that is both pragmatic and visionary, and is intended to guide people to emulate sustainable natural cycles, where all discarded materials are resources for others to use. Zero waste means designing and managing products and processes to reduce the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing zero waste will eliminate all discharges to land, water or air that may be a threat to planetary, human, animal or plant health" (International Zero Waste Alliance, 2007). Ultimately, zero waste "maximises recycling, minimises waste, reduces consumption and ensures that products are made to be reused, repaired or recycled back into nature or the market place" (Grass Roots Recycling Network, 2004). This concept may be applicable to any part of the waste stream, either in production or consumption.

In this thesis emphasis will be placed on applying the concept of zero waste to post-consumer rather than production waste. As such, this research is an attempt to apply Sustainable Development criteria to post-consumer waste management in South Africa by testing whether it is possible to achieve zero waste in urban and rural areas as set out in the Polokwane Declaration. At present in South Africa, little or no research has been carried out to assess the possibility of applying waste reduction techniques within communities in rural and urban areas, whose waste management systems are the responsibility of municipalities, which would render such systems more sustainable.

In order to realise the aim of the research, a conceptual zero waste model was developed as the main tool for assessing the possibility of achieving zero waste in the case study areas. This conceptual model is a synthesis of waste reduction techniques applicable to post-consumer waste, and is based on achieving environmental, social and economic sustainability. Since municipalities are responsible for waste management systems in rural and urban areas, Institutional sustainability was added to the criteria required for achieving sustainable development. The development of the conceptual zero waste model was the first objective of this research given that such a model does not exist within the South African context of post-consumer waste management.

The conceptual zero waste model was then applied to case studies from rural and urban areas. These case studies were selected due to differences in service delivery, household income levels and the existing waste management systems. In each case study, the existing waste management system was assessed using the four sustainability criteria: environmental, social, economic and institutional. The environmental assessment focused on existing waste collection and disposal methods available in the area as well as application of waste minimisation and recycling methods. The social assessment focused on existing attitudes of households towards the management of their waste. The economic assessment focused on the costs associated with maintenance of existing waste management systems. Institutional assessment focused on the ability of the municipalities in these areas to finance and administer these systems. This sustainability assessment of the existing systems was the second objective of the research.

The third objective required the development of zero waste schemes that could be applied in the case study areas. The development of these schemes was based on achieving a sustainable waste system in each area. The environmental, social, economic and institutional impacts that could arise from applying the proposed schemes were compared with the impacts arising from maintaining the status quo. This analysis was carried out on a theoretical basis due to lack of application of the proposed schemes by the

CHAPTER 2

2. LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to give a general overview of waste management within the South African context as background for the development of a conceptual zero waste model in Chapter 3. The discussion will focus on municipal solid waste (MSW), with emphasis being placed on the waste fractions arising from a household or commercial establishment within a residential area. These fractions are referred to as post-consumer waste in this thesis. The key terms that will be used in the thesis, which include waste management, the waste hierarchy, waste minimisation, recycling and zero waste will be defined and elaborated on. Delineation will also be made between waste management approaches in developed and developing countries, and the need for and application of zero waste within the South African contexts will be discussed.

The chapter consists of seven sections. Waste management principles, beginning with the formal definition of waste in South Africa will be discussed in Section 2.2, while waste minimisation and recycling will be discussed in Section 2.3 and 2.4 respectively and Section 2.5 will be an introduction of the zero waste concept. This introduction will be followed by a review of existing waste management practices in developed and developing countries in Section 2.6, while Section 2.7 will focus attention specifically on waste management practices in South Africa. Section 2.8 will be a summary of the main points discussed in the chapter. The summary will also highlight the need for assessing the possibility of achieving Zero Waste in South Africa, which is the main focus of this thesis.

2. 2 Overview of waste management

2.2.1 Definition of waste

Waste generally means 'something unwanted'. Its precise definition and scope however, differs from one country to another (Kaseva and Mbuligwe, 2005). For the purpose of this thesis, the use of the term 'waste' will be as defined in the South African Constitution of

1996 and related Acts including the Environment Conservation Act (Act 73 of 1989) and the National Environmental Management Act (Act 107 of 1998)

Waste, as per ECA is defined as

". . . any matter, whether gaseous, liquid, or solid, or in any combination thereof, originating from any residential, commercial or industrial area or agricultural area identified by the Minister as an undesirable or superfluous by product, emission, residue or remainder of any process or activity."

The Minister of Environmental Affairs and Tourism (hereafter referred to as the Minister) provided a definition of waste in Government Gazette No. 12703 of 24 August 1990:

"For the purpose of the definition of "waste" in Section 1 of the Environment Conservation Act [the Minister identifies] as an undesirable or superfluous by-product, emission, residue or remainder of any process or activity, any matter, gaseous, liquid or solid or any combination thereof, originating from any residential, commercial or industrial area which:

a) is discarded by any person
b) is accumulated and stored by any person with the purpose of eventually discarding it with or without prior treatment connected with the discarding thereof or
c) is stored by any person with the purpose of recycling, re-using or extracting a useable product from any such matter, excluding –
    i) water used for industrial purposes
    ii) any matter discharged into a septic tank or French drain sewerage system
    iii) building rubble used for filling or levelling purposes
    iv) any radioactive substances discarded
    v) any minerals, tailings, waste rock or slimes produced;
    vi) ash produced by or resulting from [...] the generation of electricity."

Waste is classified into three basic groups (Hall & Ball, 1989):

a) Inert wastes: These are wastes that are not considered intrinsically harmful and should not make a negative impact on the environment unless they are disposed of in poorly selected disposal sites. Examples include builder's rubble, tyres and soil.

b) General wastes: "A generic term that applied to waste that does not pose a significant threat to public health or the environment if properly managed" (Department of Water Affairs and Forestry, 1998). These wastes will exert a negative impact on the environment when the products of their breakdown (leachate and landfill gas) are allowed to pollute the environment. Examples include domestic, business, garden refuse and industrial wastes (DEAT, 2007).

c) Hazardous wastes: These include all wastes not considered in the other two categories, defined in the European Union Special Waste Regulations (1996) as "that group of wastes which because of quantity, concentration, physical, chemical or infectious characteristics may cause ill health, increased mortality to life or adversely affect the environment or pose an immediate or potential threat when improperly treated, stored, transported, disposed off or otherwise managed and exhibits the characteristics of corrosivity, toxicity, inflammability, volatility, explosivity or radioactivity.

2.2.1.1 Post-consumer waste

In terms of the waste stream being studied, the emphasis in this thesis is on MSW, with special emphasis being placed on domestic solid waste where applicable. Therefore, unless otherwise stated, the term 'waste' shall apply to solid waste arising from a residential dwelling or commercial establishment within a residential area. Both waste streams are collectively defined as post-consumer waste in this thesis.

2.2.1.2 Fractions for study

Post-consumer waste consists of two major fractions of solid waste: the dry fraction and the wet fraction (Matete and Trois, 2008). The wet fraction consists mainly of purtriscibles while the dry fraction consists of recyclables. The purtriscibles can be composted, while the recyclables can be collected and sold to recycling companies. The research reported in this thesis focuses on the four main constituents of the recyclable fraction: paper, cans, plastics and glass. There are a number of reasons for choosing these constituent materials within the recyclable fraction. Firstly, they form the bulk of the recyclable fraction, and are easily the most consistent constituent materials. Secondly, these materials are well known to the public, as a number of recycling schemes have been set up by South African manufactures in the last few years, with collection areas located in public places such as schools and shopping complexes(Collect-a-can, 2005; Mondi; 2005; Consol, 2007; Nampack, 2007). These schemes have also been well supported by marketing strategies such as schools competitions (DEAT, 1999a; Botha, 2005; Zwane, 2005; Consol 2007; Nampack, 2007), making the materials well known brands. A third, though secondary reason for choosing these materials, is that they have been researched extensively in developed countries, therefore published data is available for comparison, data which is scarce in developing countries such as South Africa. Finally, green or garden waste was not included in the research since reuse of this waste, either by composting or anaerobic digestion, has little in common with materials recycling (Bjorklund and Finnveden, 2005).

2.2.2 Waste management

The fact that waste arises from human activities means that it must be effectively managed if it is not to have an adverse effect on the environment. This brings about the need for waste management (WM). The most comprehensive, though not formally recognised definition of WM is given in WIKIPEDIA (2007), which defines WM as "collecting, transporting, processing, recycling or disposing of waste materials, usually ones produced by human activity, in an effort to reduce their effect on human health or local aesthetics or amenity". This definition gives rise to two main ways in which WM can be defined: purpose and process. In terms of purpose, WM is defined as "a public service providing citizens with a system of disposing of their waste in an environmentally sound and economically feasible way" (Beigl et al., 2007). A more comprehensive definition in this regard is to describe WM as "any activity that has the target to minimise waste generation and pollution at source and to promote a hierarchy of waste management practices, namely reduction of waste at source, reuse, recycling (and safe disposal as a last resort)" (Mega-Tech Inc, 2004). Both these definitions are encompassed in the formal definition of WM in South Africa, which is "the measures, including the avoidance of the generation of waste, that are necessary to prevent or, where prevention is not possible, to minimise the amount of waste that is produced and the risk posed by waste to health and the environment" (DEAT, 2007). With regards to process, the Dictionary of Civil and

Environmental Engineering [DCEE] (1999) defines WM as "the management of waste at all stages from generation to ultimate disposal, including the management of reclaimed or recycled fractions out of the waste stream". These definitions indicate that WM should be thought of in terms of purpose and process, and at the same time cover all aspects and types of waste. Since this thesis is focused on MSW, appropriate definitions will be given with regards to Solid Waste Management (SWM).

SWM is "a planned programme for effectively controlling the generation, storage, collection, transportation, processing, reuse, conversion or disposal of solid wastes in a safe, sanitary, aesthetically acceptable, environmentally sound and economic manner" (DCEE, 1999). It is important to note that the DCEE definition has global application and can be refined to suit existing WM conditions within a specific country. As such, SWM is defined within the South African context as "a process of collection of waste efficiently from all sources through to disposal in controlled sites" (WRC, 1996). The actual process of managing waste is termed a waste management strategy [WMS] (DEAT, 1999b). WMS implies a holistic approach to waste management where waste is dealt with in an environmentally responsible way from generation at source to ultimate disposal (Hall, 1989). WMS must therefore be seen as an orderly process governing the ultimate destination of the various components of the waste stream (Theron, 1992). This strategy is divided into six functional components as shown in Figure 2.1.

It is in the light of the model proposed by Tchobanoglous et al. (1977) that waste reduction strategies can be adopted and used efficiently and effectively to reduce the amount of waste that is being generated and disposed of in landfills in South Africa and worldwide. Understanding of the waste hierarchy is an important development in achieving these waste reduction strategies.

2.2.3 Waste hierarchy

There are three key objectives for waste management strategies as identified by Robinson (1996):

a) to reduce the amount of waste that society produces
b) to make the best use of the waste produced
c) to choose waste management practices that minimise the risk of immediate and

future environmental pollution and harm to human health.

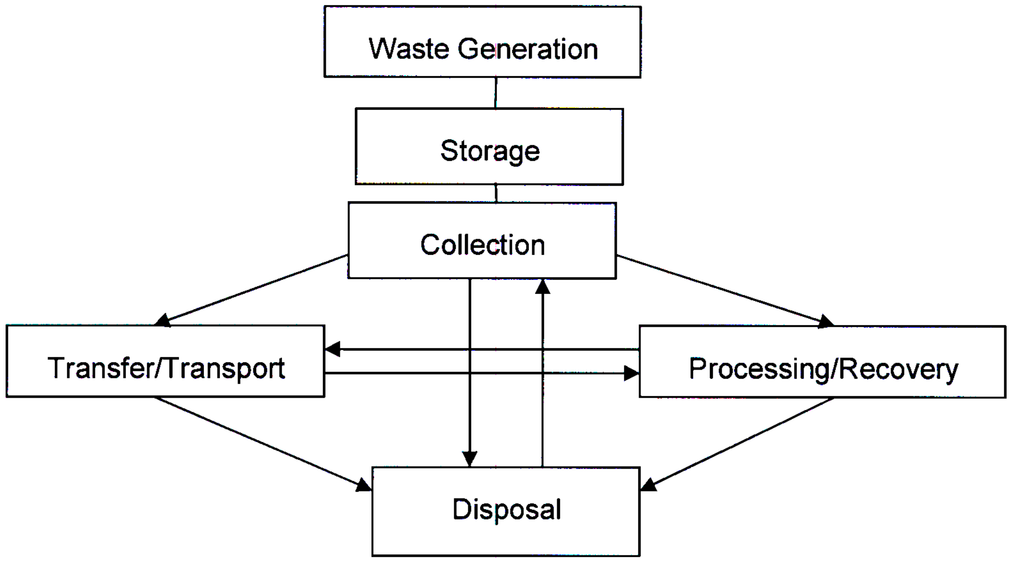

Figure 2.1: Functional elements in a Solid Waste Management System (Tchobanoglous et al., 1977)

In order to achieve these objectives, different waste management options can be ranked into a hierarchy giving a wide scope of their relative environmental benefits and disbenefits. This hierarchy is shown in Figure 2.2. The hierarchy prescribes waste minimisation (source reduction) as the most desirable option, followed by reuse, materials recycling, energy recovery and landfilling of stabilised waste as the last resort (Brisson, 1997). According to Abbu (2006), the hierarchy is "a holistic approach to solid waste management that is aimed at [waste] prevention, reduction, recovery and recycling". The national waste management strategy [NWMS] (DEAT, 2000b) encapsulates Abbu (2006) by stating that the waste hierarchy "promotes waste prevention, minimisation, recycling and re-use, with treatment and disposal being seen as the last resort options." The hierarchy is adopted within the principles of sustainable development, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [World Commission on Environment and Development (1987) cited in Macris and Geogakellos (2006); Glavic and Lukman (2007); Ness et al. (2007)].

Waste Hierarchy	
Cleaner Production	Prevention
	Minimisation
Recycling	Re-Use
	Recovery
	Composting
Treatment	Physical
	Chemical
	Destruction
Disposal	Landfill

Figure 2.2: The Waste Hierarchy (DEAT, 1999a)

The various options included in the waste hierarchy are further discussed:

a) Reduction: This is the prevention or minimisation of waste consistent with technical and financial constraints, and should be the main priority of a sustainable waste management system (DEAT, 1999a).

b) Reuse: This is defined in DCEE (1999) as the return of a commodity or product into the economic stream for use in exactly the same form and kind of application as before, without any change in its identity. Although this is an attractive and viable option, decisions regarding it should be based on sound information, with regards to specific instances and wastes.

c) Recovery: The third level in the waste hierarchy encompasses materials recycling, composting and energy recovery. DCEE (1999) defines recovery as a process of retrieving materials or energy from waste.

d) Treatment: the "use of any method, technique or process that is designed to change the physical, biological or chemical character or composition of a waste, to reduce its toxicity in order to minimise the impact of the waste on the environment (DEAT, 2007).

e) Disposal: This is the fifth and last level of the waste hierarchy. All waste that has by-passed the first three levels is disposed of in landfills and incinerators (DWAF, 1998; DEAT, 1999a).

Robinson (1996) stated that by the end of the 1990s, the landfill disposal of wastes will be seen as a last resort as waste management will increasingly be based on prevention and minimisation. However, this has not been the case as landfills are still being used to dispose of a greater fraction of waste than is being handled by the combination of reduction, recycling and recovery (DEAT, 1998; Buenrostro and Bocco, 2003 and Engledow, 2005). Differentiating between waste minimisation (reduction) and recycling shows why this is the case.

2.3 Waste minimisation

It is within the framework of a waste hierarchy that waste minimisation emerges as a tool to integrate reduction, reuse and recovery (Matete and Trois, 2008). Waste minimisation is "the application of a systematic approach to minimise the production of waste at source" (Environment and Pollution Prevention Agency, 1996) or "any activity that is undertaken by the generator of waste to prevent or reduce the volume and/or environmental impact of waste that is generated, treated, stored or disposed of" (DEAT, 2000) or "the use of source reduction and/or environmentally sound recycling methods prior to disposal of waste" (United States Environmental Protection Agency, 2008). These definitions, from the United Kingdom (UK), South Africa (SA) and the United States of America (USA) respectively, generally apply to waste generated in industrial manufacturing processes, and are made up of the following three basic steps (Enviros March, 1999):

a) the collection and analysis of new and existing data to identify and quantify the sources of waste
b) the generation, prioritisation and the selection of a solution to reduce or eliminate waste
c) the implementation, monitoring (through the collection and analysis of data to check the performance of the waste minimisation option) and adjustment and the

re-implementation of the solution or implementation of a different solution

This waste minimisation methodology has been demonstrated by the formation of waste minimisation clubs within industry (Phillips et al., 1999; Read, 1999a; Barclay et al., 2000 and Mega-Tech Inc., 2004). The introduction of minimisation methodology within the UK has resulted in improved resource efficiency and as such provides a model that points the way to more sustainable waste management (Phillips et al., 1999; Read, 1999a). A similar conclusion applies to SA, where Barclay et al. (2000) and Barclay and Buckley (2002) have shown that the concept of waste minimisation clubs is a feasible approach to encouraging sustainable industrial development. Mega-Tech Inc. (2004) states that there are approximately 30 waste minimisation clubs in SA. However, in contrast to these significant developments within industry, municipal waste minimisation has been neglected until quite recently, with emphasis being placed on research into recycling behaviour and comparatively less attention being paid to waste minimisation behaviour (Tonglet et al., 2004).

There are few detailed published reports on MSW centred waste minimisation in the UK (Tonglet et al., 2004; Fahy and Davies, 2007), while research on MSW in SA is focused on waste auditing for commercial establishments and the operational aspects of running recycling centres rather than household recycling or waste minimisation (Mkhize and Mgingqizana, 2002; Mgingqizana, 2002). Part of the reason for this focus is that commercial establishments are able to finance these projects, while Local Municipalities who are responsible for household waste management may lack the necessary funds to promote and implement such projects at household level (Local Municipal Systems Act [Act 117 of 1998]; Fiehn, 2007; Godfrey and Dambuza, 2007).

Studies in the UK suggest that household waste minimisation behaviour may be divided into two components: waste minimisation at point of purchase and waste minimisation through repair/re-use (Barr et al., 2001; Tonglet et al., 2004). Barr et al. (2001) indicate that both waste minimisation components are underpinned by "environmental values, attitudes that stress a moral obligation and concern towards the environment, along with citizenship beliefs, emphasising environmental rights and responsibilities". Tonglet et al. (2004) tentatively suggest that overall waste minimisation behaviour is likely to be influenced by concern for the environment and the community and is likely to be inhibited by perceptions of inconvenience and lack of time and knowledge, while repair/reuse is also influenced by ability to perform the behaviour and physical or situational factors, whereas buying to reduce waste may contain a moral dimension.

Although these are results from two case studies, it is not feasible to generalise them for all households in the UK, let alone on a global scale, due to the small number of households represented. What these studies have shown though is that waste minimisation within households has not been researched in depth and hence is not a well understood dimension of the waste management behaviour. This trend in lack of research in waste minimisation had been noticed by Goddard (1995) in a review of extensive literature on alternative waste management policies in North America. Furthermore, Goddard (1995) stated that there was virtually no information on what the source reduction potential in the household sector was, and equally important, there was no information on what it would cost to achieve high levels of source reduction at household level, which is the least costly waste management option as discussed in Section 2.2.3.

From the preceding discussion, it can be concluded that waste minimisation is a broad and not well studied concept, and as such, for any study being undertaken within its scope, the definition being used must be clearly stated. Hence for the purpose of this research, waste minimisation is defined as "actions taken by householders to minimise their household waste, either at point of purchase, or within the house by reusing or repairing products rather than replacing them" (Tonglet et al., 2004). The benefits of waste minimisation include conservation of resources, avoided costs of landfilling and recycling, extension of landfill lifespan and reduction in pollution, especially greenhouse gases that contribute to global warming (US EPA, 2007).

Due to the prevalence of recycling within current waste management systems, recycling is often confused with waste minimisation. This is because not enough attention is generally paid to waste minimisation initiatives such as reduction and reuse (Tonglet et. al, 2004). This is typical of waste management strategies globally. In developed countries though, reuse, reduction and recycling are well established, yet findings indicate that recycling and waste minimisation represent separate dimensions of waste management behaviour (Barr et al., 2001; Tonglet et al., 2004). Due to the nature of recycling and its importance within waste management strategies, recycling warrants discussion on its own.

2.4 Recycling

Recycling has often touted as the universal "panacea" to the apparently growing waste management problem which is being experienced throughout the world (Lombard, 1992). This can be seen in the plethora of studies on recycling, which are published mainly in peer-reviewed journal publications such as Resources, Conservation and Recycling (for example, Goddard, 1995; Chan, 1998; Ekvall, 2000; Ackerman and Gallagher, 2002; Argawal et al., 2004; Hansmann et al., 2006; Tonglet et al., 2006 and Fahy and Davies, 2007) and Waste Management (for example, Haque et al., 2000; Williams and Taylor, 2004; Gonzalez-Torre and Adeso-Diaz, 2005; Woodward et al., 2006; Kofoworola, 2007; Tsiliyannis, 2007 and Matete and Trois, 2008), and to a lesser degree in Journal of Cleaner Production (for example, Ekvall, 1999; Ross and Evans, 2003 and Greyson, 2007) and Habitat International (for example, Joseph, 2006 and Xianbing et al., 2009). These studies range across different disciplines; disciplines which include economics, psychology, sociology, engineering, law, communication, and social marketing (Hornik et al., 1995). Yet despite the available research, recycling accounts for about 30% of MSW management in the United States of America (Agarwal et al., 2004; US EPA, 2008), less than 30% in most European countries (Hansmann et al., 2006), with less than 25% in most local authorities in the UK (Aspinwall and Cain, 1997; Parfitt et al, 2001; McDonald and Oates, 2003; Woodard et al., 2001 and Tonglet et al., 2004), and significantly less in developing countries, for example Brazil, India, Mexico, South Africa and Tanzania (Gupta et al., 1998; Bernache, 2003; Buenrostro and Bocco, 2003; Agarwal 2004; Kaseva and Mbuligwe, 2005; Colon and Fawcett, 2006; Rathi, 2006). The poor recycling rates achieved in different countries highlight the need for research into other areas of the Waste Hierarchy as discussed in Section 2.3. What follows is a brief analysis of recycling definitions, objectives of recycling, facts about recycling, the factors determining recycling behaviour and finally, the impact of recycling commodity prices on the economic benefit of recycling schemes. The analysis is important given the fact that recycling and waste minimisation are key components of the zero waste concept. This importance will be demonstrated in the conceptual model that will be developed in Chapter 3.

2.4.1 Definitions

The concept of recycling must be defined broadly enough to include any form of recovery of material from waste for the purpose that would otherwise require the consumption of resources (Baum and Parker, 1974). This concept is illustrated in the definitions provided by Robinson (1996), WRC (1996), DCEE (1999), Read (1999b) and DEAT (2000b). Robinson (1996) defines recycling as "a closed loop system, the purpose of which is to optimise the utilisation of resources to the overall benefit of humankind while minimising the production of waste". Similarly, WRC (1996) defines recycling as "the recovery of materials from the waste stream, with the recovered materials serving as 'raw material' input in the manufacture of a new product. Furthermore, DCEE (1999) defines recycling as "the separation of a given waste material from the waste stream and processing it so that it may be used again as a raw material for products which may or may not be similar to the original", while for Read (1999b) recycling is a broad term referring to the conversion of waste ("discarded material with no worth") into a useful material ("resource with an economic value"). Finally, according to DEAT (2000b), waste recycling "refers only to initiatives aimed at the external recovery, re-use and/or reprocessing of post-consumer and post-production wastes and does not include the reuse of production waste".

An assessment of the above definitions leads to further considerations. Firstly, Baum and Parker (1974) discuss recycling as a concept rather than a definition, which indicates that recycling was still evolving at that time and had not yet reached a state where it was warranted for it to be defined specifically. Secondly, the definitions by Robinson (1996), WRC (1996) and DCEE (1999) show that the aim of recycling was to close the materials loop, even though an open loop will exist as defined in DCEE (1999). Also, in contrast to Baum and Parker (1974), these recent definitions are specific rather than general, indicating the advance of research on recycling since the concept was derived. Thirdly, while the recent definitions focus on materials flow in production and consumption, Read (1999b) adds another dimension to the recycling definition: waste as a "resource with an economic value". This means that waste is both a production and an economic inefficiency that needs to be reduced, hence the need to apply the Waste Hierarchy to both production and post-consumer waste. Finally, although the DCEE (1999) definition is the most comprehensive and practical to use for any given study on recycling, the research in this thesis is focused on South Africa, therefore the DEAT (2000b) recycling definition will be used even though it is less comprehensive than DCEE (1999).

The DCEE (1999) definition of recycling gives rise to two types of recycling: Closed Loop and Open Loop Recycling. According to Miller (1996), closed loop recycling, also known as primary recycling, is the most desirable type of recycling. Here, post consumer waste is recycled to produce new products of the same kind in place of virgin input material (Diaz and Warith, 2006). Conversely, open loop recycling, which is also known as secondary recycling, is a less desirable type of recycling (Miller, 1996). It is defined as the recycling of a material from one product life cycle into another (Ekvall, 2000). The issue of desirability arises from the fact that primary recycling reduces the amount of virgin material used in making a product by 20 – 90%, whereas secondary recycling reduces the use of virgin material by only 25% at most (Miller, 1996).

As with recycling types, the recycling process has two basic approaches (WRC, 1996): source recycling and mixed waste recycling. Source recycling involves at-source separation of recyclable materials by the waste generator and separate collection and transportation of these materials to recycling markets either by the generators themselves or by a service provider. Several collection systems exist worldwide for recyclables (Gonza'lez-Torre and Adenso-Dia'z, 2005):

a) Kerbside collection: Separated recyclable fractions in clearly identifiable bags are set out next to those for general refuse by residents. Although this is the most costly collection system due to the high number of collection points served, it is the most convenient for users and ensures high participation rates.
b) Drop off points: this method involves defining an area where a set of large bins is located for collection of different items. These large bins, also known as banks, are owned by the recycler or its agent and are sited at convenient points where permission can be obtained from the land owner (Davies and Freeman, 2000). Residents bring the separated recyclables and 'drop them off' at these points. These bins are located further from source, reducing convenience to residents.
c) Clean point: These serve as centres for selective reception and storage of recyclables not collected in the two other systems. Materials included in this category are mainly bulk recyclables, examples being home appliances and

computer equipment. These are even further from the source of waste and are the least convenient to users.

Mixed waste recycling can be accomplished on a large scale by collecting mixed urban waste and transporting it to materials recovery facilities (MRFs) (Miller, 1996). Depending on the type of plant, processing can either be capital intensive or labour intensive. The success of these plants depends on the processing costs, the quality of the recyclable materials produced and the availability of markets for these materials (Lombard, 1997). The quality of recyclables can be low due to contamination arising from co-collection with wet waste (City of Cape Town, 2007).

Of the two recycling approaches, at-source recycling is the preferred method given its advantages over mixed waste recycling. Miller (1996); DEAT (2000b); (Medcities and ISR, 2003) note the following: source separation produces little air and water pollution and has moderate operating costs; source separated materials are also cleaner and can usually be sold for a higher price and; source separation also educates people about the need for waste reduction, reuse and recycling. However, at-source separation also has disadvantages when compared with mixed waste recycling: overall costs are higher than mixed collection system costs; waste generators bear the cost for source separation; at-source separation requires a high level of participation by the residents, which in turn needs several education and communication programmes; and the separation obtained is not unlimited, that is, the greater the number of fractions the higher the cost and; source separation requires space within households (Miller, 1996; DEAT, 2000b and Medcities and ISR, 2003).

Although at-source separation has been fairly successful in developed countries, Charuvichaipong and Sajor (2006) show that it is often assumed that waste separation can be applied to developing countries without thorough consideration of the country's particular socio-political circumstances and tradition. Charuvichaipong and Sajor (2006) further argue that although such conditions exist in developed countries, they do not necessarily exist in developing countries, where at-source separation may not be applicable. Using results from a study on at-source separation in India, Colon and Fawcett (2006) seemed to confirm this assertion. However, results from pilot projects in South

Africa (Engledow, 2005; City of Cape Town, 2007; Fiehn, 2007) show that at-source separation can be applied in developing countries. Thus it is the aim of this present study to show that the argument posited by Charuvichaipong and Sajor (2006) is not valid for all developing countries.

2.4.2 Objectives of recycling

Apart from a reduction in the amount of waste disposed of in landfills achieved by recycling, there are other important objectives for which recycling is undertaken. DEAT (1999) states that the objectives of recycling are to save resources as well as to reduce the environmental impact of waste by reducing the amount of waste disposed of at landfills. Recycling not only reduces the amount of solid waste but also mitigates the depletion of natural resources resulting from economic development (Bor et al., 2004). Recycling turns materials that would otherwise become waste into valuable resources and generates a host of benefits at every level: environmental, financial and social (Agarwal et al., 2004). The benefits of attaining these objectives are summarised in Martin et al., (2006) for household waste recycling: "it reduces demand for virgin raw materials; there are fewer environmental impacts from material extraction, processing and transportation; products made from recyclables rather than virgin materials generally consume less energy in manufacturing; and lower down the hierarchy, less waste is disposed of by the more environmentally damaging methods such as incineration or landfill". This lower environmental impact of recycling compared with incineration and landfilling is illustrated in Figure 2.3.

2.4.3 Facts about recycling

The following facts about recycling need to be established in order to avoid confusion about the nature and impact of recycling on waste management systems. These are recycling potential and markets for recycled waste, which will be discussed in this section and the determinants of recycling behaviour for households which will be discussed in Section 2.4.4. Understanding these facts will remove the misunderstanding that this waste management technique is 'the "universal panacea" to the apparently growing waste management problem' as stated in Section 2.4. Recycling should not be seen as a solution to the waste problem, but as part of the process of reducing volumes of waste needing disposal.

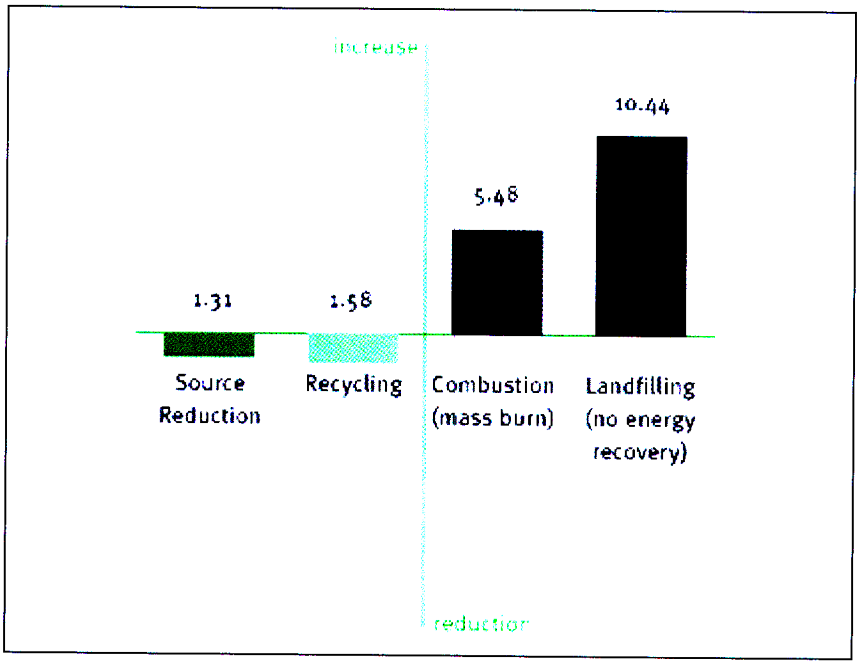

Figure 2.3: Metric tons of carbon emissions generated per US ton of waste (Waste Watch, 1999)

2.4.3.1 Recycling Potential

In an assessment of recycling potential in the United States, Lombard (1992) concluded that about 25% of Municipal Solid Waste could be realistically recycled, while reaching more than 25% would require a "Herculean effort". Conversely, Miller (1996) showed that by 1993, 22% of MSW in the United States was being recycled or composted. Miller (1996) further stated that pilot studies in several US communities had shown that 60 – 80% recycling and composting rates were possible. However, the US EPA (1999) shows that the United States recovers as much as 30% of its MSW. Irrespective of the actual recycling rates, what remains clear is that recycling can only account for a fraction of the waste generated. This point underscores the importance of applying waste minimisation techniques in managing post-consumer waste, bearing in mind the objective that no waste should be disposed of by landfill or any other method of disposal. This objective is embodied in zero waste, which will be defined and discussed in Section 2.5.

2.4.3.2 Markets for recycled materials

One of the major factors influencing the viability of recycling is the availability of markets for recycled materials (WRC, 1996). Historically, Rimberg (1975) stated that the markets for recyclables were unstable, that is, the prices paid were inadequate to sustain large scale recycling. Later research shows that this is still the case (WRC, 1996; Miller, 1996; Lombard, 1997; DEAT, 2000b; Rubin, 2001; Wiener and Matthews, 2003; Liebenberg, 2007). In order to address this lack of markets for recyclables, various policy measures were formulated and implemented globally to varying degrees of success (DEAT, 2000b). According to DEAT (2000b), these policy instruments can be grouped into four categories: regulatory approaches; market based instruments; education initiatives; and co-regulatory and voluntary initiatives. The success of these measures in creating markets for recyclables has varied considerably, a prime example being the failure of the Topfer Regulations in Germany, which was one of the first countries to apply them (Lombard, 1992; Goddard, 1995; Lombard, 1997).

The failure of the Topfer regulations in Germany showed that bans, taxes and deposits were political instruments that created an illusion that the waste problem was being solved (Lombard, 1992; Goddard, 1995). Furthermore, Goddard (1995) stated that no provision was made to ensure a rough balance between the greatly increased supplies of separated materials handled under the system and the capacity to process them, so that much of the material had to be exported, causing disruptions in other European countries' secondary materials markets. This failure of the regulations was affirmed by Lombard (1997) who stated that glass and plastic recycling industries in Europe were in disarray due to oversupply of material, and this created material stockpiles that were either incinerated or dumped in other countries. This preceding discussion underscores the fact that policy measures cannot sustain recycling apart from the participation of consumers.

Unless there are sound strategic considerations relating to scarce materials, market forces and not legislation should determine the extent of resource recovery (Lombard, 1997). With regards to consumer goods, Miller (1996) indicates that consumers can increase the demand for and economic viability of recycling by buying goods made from recycled materials, especially if this involves closed loop recycling as discussed in Section 2.4.1. Throne-Holst et al. (2007) note that it is in the buying process that households can choose among products offered by producers and retailers in the market and through their choices consumers actually can decide which products can gain market share. There are two ways in which this can be achieved: environmental education of consumers and proper price signals for products in the markets. These two mechanisms are summarised in Goddard (1995), who argues that solid waste management authorities should place priority on setting the correct prices for environmental products and on disseminating the appropriate information to the consumer about how to make better choices. This will lead to better and more reliable information on waste flows and composition and will elicit appropriate behaviour from households (Goddard, 1995). Understanding the determinants of household recycling behaviour is important in achieving these goals.

2.4.4 Determinants of recycling behaviour

There are basically two schools of thoughts in terms of determinants of recycling behaviour: the 'North American' approach (Hornik et al., 1995) and the Theory of Planned Behaviour (TPB) (Tonglet et al., 2004). Both approaches are based on Social Science methodologies. Hornik et al., (1995) group the determinants of recycling behaviour into five categories: extrinsic incentives, intrinsic incentives, internal facilitators, external facilitators, and demographic variables, while TPB (Tonglet et al., 2004) identifies environmental attitudes, situational and psychological variables as important predictors of recycling behaviour. Recent studies (Barr et al., 2001; Tonglet et al., 2004) show that TPB can model and predict recycling behaviour very well in developed countries with their formalised household recycling activities, while the Hornik et al., (1995) approach would be more suitable for developing countries given the informal nature of their household recycling activities.

In developing countries, people choose to participate in recycling for a variety of reasons (Gonza'lez-Torre and Adenso-Dia'z, 2005). Tonglet et al., (2004) suggest that recycling attitudes are the major determinants of recycling behaviour, and that these attitudes are influenced firstly, by having the appropriate opportunities, facilities and knowledge to recycle, and secondly, by not being deterred by physical recycling constraints, that is, time, space and inconvenience. These conclusions are based on research carried out in developed countries, for example, Spain (Gonza'lez-Torre and Adenso-Dia'z, 2004) and the UK (Barr et al., 2001 and Tonglet et al., 2004). Comparative studies show that this may also be the case for medium to high income groups in developing countries, whereas revenue that is gained from selling recyclables is of importance to the lower income group (Borland et al., 2000; Liebenberg, 2007).

Since South Africa is classified as a developing country, it can be assumed that the determinants of recycling behaviour would be those identified by Hornik et al. (1995), hence for the purpose of this thesis the determinants need to be briefly expanded on. Extrinsic incentives include monetary rewards, societal influence through expected behaviour for community members and, laws and regulations such as by-laws, while intrinsic incentives focus mainly on internal psychological drivers of recycling behaviour (Hornik et al., 1995). Internal facilitators include variables such as awareness of the importance of recycling and knowledge about recycling programmes, while external facilitators include time, money, and effort needed to prepare, store and transport the recyclables, and demographic variables include education, age, type of dwelling and level of income (Hornik et al., 1995).

2.4.5 Benefits/disbenefits of recycling

While Section 2.4.4 focused on the social aspects of recycling, this section will focus on the benefits and disbenefits of recycling the MSW fractions identified in Section 2.2.1.2. The following is a summary of the benefits and disbenefits of recycling (Hornik et al., 1995; Miller, 1996; Hugo, 2004; Engledow, 2005; Mondi, 2005; Diaz and Warith, 2006; City of Cape Town, 2007):

Paper

The benefits of recycling paper are: more landfill space is saved by recycling paper more than any other material - recycling a tonne of waste paper saves 3m^3 of landfill space; recycling of paper does not eliminate deforestation, but 17 less pines are used with each ton of paper recycled; energy consumption is reduced by 40%; water usage is reduced by 55%; water pollution is reduced by 35% and; air pollution is reduced by 70%.

The disbenefits are: paper contamination with wet fractions increases handling costs; for particular uses, recycled paper is of lower quality than virgin paper; ink removal plants are costly to build; forecasting of economic viability is difficult due to changing market conditions; and paper cannot be recycled indefinitely.

Plastic

The benefits of recycling plastic are: plastic recycling reduces air pollution and conserves oil and natural gas (non-renewable resources); savings in landfill space due to considerable volume that plastic can occupy; and there is no plastic material that cannot be recycled one way or another.

The disbenefits are: plastic from 'non-packaging' sources is rarely recycled; vast number of plastic types increases handling and sorting costs; plastic is lightweight, hence expensive to collect, sort and transport; virgin resins for plastic manufacture can be cheaper than recycled ones; and some resins are difficult to clean thereby increasing costs.

Glass

The benefits of recycling glass are: the energy required to recycle glass is 9.23 GJ/ton compared to 14.1 GJ/ton for virgin raw materials; glass can be recycled indefinitely and made into food containers; and labels and food residues burn off in furnaces (1800^0 Kelvin), hence no preparation is required before processing.

The disbenefits are: glass must be hand sorted by colour for most markets; shipments of glass are often contaminated with unusable glass; and forecasting of economic viability is difficult due to changing market conditions.

Cans (Tin and Aluminium)

The benefits of recycling cans are: recycling tin uses 40% (9.43 GJ/ton) of energy used in primary production (25.2 GJ/ton); recycling of tin reduces air pollution by 85%, water consumption by 40 - 76% compared with primary production; both steel and aluminium can be recycled indefinitely without loss in quality; recycling aluminium uses 5% (11.7 GJ/ton) of energy used in primary production (140 GJ/ton), produces 95% less air pollution (emissions of perfluorocarbons – PFCs) and 97% less water pollution.

The disbenefit in the long run is that recycling of cans consumes more energy than the use of refillable containers made from glass or plastic.

From the preceding discussion of the benefits and disbenefits of recycling the four waste fractions identified for study, it can be concluded that producing materials from recyclables is often, but not always, less energy intensive and has less global warming impact than producing materials from virgin resources (Bjorklund and Finnveden, 2005). However, environmental and social impacts of recycling are not the only factor that has to be considered, there are also the economic impacts, discussed here under recycling prices.

2.4.6 Recycling prices

The discussion on recycling would not be complete without mentioning the impact of the prices paid for recyclables by manufactures. These prices can have a significant influence on the viability of recycling schemes (DEAT, 2000b; Ackerman and Gallagher, 2002; Stromberg, 2004 and Xianbing, Masaru and Yasuri, 2009), especially when the recycling schemes are not subsidised and therefore need to be financially self sustaining (Mokua, 2000). This discussion is important because MSW management authorities in developing countries lack the necessary financial resources to subsidise the recycling schemes if they are implemented (Fourie, 2006). On the other hand, most MSW management authorities in developed countries, which are required to recycle by legislation through the setting of recycling targets (Goddard 1995; Aspinwall and Cain, 1997; Lombard 1997; Parfitt et al., 2001), subsidise the recycling schemes (Goddard, 1995; Lake et al., 1996; Read 1999; Woodard et al., 2006). This implies that while their operational aspects of theses recycling schemes can be transferred to developing countries, their economical aspects are not transferable.

It has been shown in this section that recycling alone cannot effectively reduce the amount of MSW that is being generated by households especially. Furthermore, it was also shown in Section 2.3 that waste minimisation is a waste management technique that can be used to reduce MSW generation by households. Moreover, the waste generated after applying waste minimisation can, at least theoretically, be recycled. Hence it can be deduced that a combination of waste minimisation and recycling should be able to reduce the MSW needing disposal significantly. This combination of waste minimisation and recycling which reduces the amount of waste needing disposal to a minimum, and ultimately to 'zero', is embodied in the concept of zero waste. This concept will be explored in this thesis as a solution to managing the increasing MSW volumes generated by households.

2.5 Zero waste

Goddard (1995) argues that solid waste management has always been treated as a command-and-control problem rather than a malfunctioning of the market system; with end-of-pipe technology (recycling, incineration and landfill) being financed with tax and subsidy arrangements. This argument is supported by Wiechers et al. (2002) who shows that these command-and-control approaches have limitations when it comes to the management of waste. Greyson (2007) further adds that although nations differ in their enthusiasm for applying command-and-control approaches to waste management, they share a common approach: incremental improvement. These statements highlight the need to think of waste management as a multidisciplinary field and the need for a preventative approach in managing waste rather than an incremental change. Hence it is proposed in this thesis that the way to deal comprehensively with the waste problem is to shift from incremental change involving only recycling, to waste minimisation and recycling and finally to the preventative approach: zero waste. This preventative approach is summarised by Robert (1991, cited in Greyson, 2007).

> "Most environmental problems are based on the same systemic error – linear processing of material. Until resources are processed in cycles – the global economy and public health will continue to deteriorate. Consequently, we will never be in a better position than we are now to make the necessary changes; every minute we delay increases the final cost."

2.5.1 Definition

Although zero waste has been discussed at length in waste management circles (Wiechers et al., 2002; Vorster and Mollekopf, 2002; Neethling et al, 2006; and Greyson, 2007), there exists no global formal definition that is approved by waste management practitioners. Conceptually, zero waste is a new planning approach for the 21st Century that seeks to redesign the way resources and materials flow through society, taking a 'whole system' approach (Zero Waste Kovalam, 2004). Thus, zero waste defines the discipline required to create more sustainable interaction with the natural world (Liss, 1997). Furthermore, zero waste maximises recycling, minimises waste, reduces consumption and ensures that products are planned to be reused, regenerated, repaired or recycled internally or back into nature or the market place (Glavic and Lukman, 2007).

Indeed implementation of zero waste is arguably the most important step to the sustainability of Earth's ecosystems as it relieves every environmental ailment from deforestation, resource depletion, global warming, energy depletion, loss of biodiversity, to toxicity of materials in the modern waste stream notes GRRN (2004). "The path to zero waste is not just more recycling, but to extract the maximum usefulness out of all the energy and resources used, because waste occurs when resources are not used efficiently" (Christopher, 2004).

For the purpose of this research zero waste is defined as the concept of using all waste produced in a certain area for activities within that area (Ali, 2005) when it is environmentally acceptable, socially equitable and economically viable, which leads to only unavoidable residual waste going to landfill (Matete and Trois, 2007).

2.5.2 Components of zero waste

Zero waste entails three important shifts from conventional solid waste management systems (Target Zero Canada, 2004):

1. It asks consumers, taxpayers and local governments to stop thinking of resources as garbage for which payment has to be made to landfill or incinerate, but to maximise reuse, repair, recycling and composting.
2. It asks businesses to seek out materials efficiencies; redesign products and packaging the community cannot reuse, repair, recycle or compost so that they can be handled that way; and extend their responsibility for the product and its packaging by establishing take-back, reuse and remanufacturing systems. This concept is known as extended producer responsibility (EPR).
3. It asks senior levels of government to shift economic incentives from virgin resources to renewable resources and to facilitate the growth of zero waste. Christopher (2004) points out that zero waste requires an economic system that rewards people and business for doing what is right: reduction, reuse and source separated recycling to maximise resource efficiency and reduce waste.

Strategies that can be used to achieve zero waste are as follows:

a) Promoting repair, resale and reuse of durable products made from fewer material types and designed for recyclability when they outlive their usefulness (Liss, 1997). It means designing for the end of the product's lifecycle, so that it can be easily disassembled for recycling harmlessly into nature or its materials recovered for use in new products (TZC, 2004).

b) Pursuing waste prevention, reuse, and repair, recycling and composting, and banning materials that do not allow for those activities (Liss, 1997). This entails putting the responsibility for materials entering the waste stream on the front-end with the manufacture, as in EPR, not on the consumer at the back-end of the product's life (Matsch, 2000).

c) Investing in resource recovery facilities that enable materials discarded by the community to be reused, recycled and remanufactured (TZC, 2004), rather than using the tax base to build new landfills or incinerators (Matsch, 2000). Matsch, (2000) further adds that the facilities would be located in appropriate places where consumers can come and drop off any unwanted item.

d) Use of legislation and economic instruments to promote zero waste. This means encouraging the use of recycled content products by manufactures (Liss, 1997) by providing economic incentives to make such processes viable. It also means cutting off subsidies on virgin material extraction, which lowers the prices of goods manufactured using these materials. When the market prices include all the subsidised costs, the more environmental-friendly product will also be less expensive (Matsch, 2000).

Having developed the strategies for zero waste, it is important to understand the concept of life cycle assessment (LCA) since it forms an integral part of the zero waste concept.

2.5.3 Life Cycle Assessment

While Ekvall, (2000) defines environmental life cycle assessment as "the compilation and evaluation of the material and energy flows and of the potential environmental impacts of the life cycle of a product", the most comprehensive definitions of LCA are given by Lindfors et al. (1995) and the International Organisation of Standardisation [ISO] (1997).

"LCA is a process to evaluate the environmental burdens associated with a product system, or activity by identifying and quantitatively describing the energy and materials used, and the wastes released to the environment, and to assess the impacts of those energy and material uses and releases to the environment. The assessment includes the entire lifecycle of the product or the activity, encompassing extracting and processing of raw materials; manufacturing; distribution; use; maintenance; recycling and final disposal; and all transportation involved. LCA addresses the environmental impacts of the system under study in the areas of ecological systems, human health and resource depletion. It does not address economic or social effects" (Lindfors et al., 1995).

"LCA is a technique for assessing the environmental aspects and potential impacts associated with a product, by compiling an inventory of relevant inputs and outputs of a system; evaluating the potential impacts associated with those inputs and outputs; interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study"(ISO, 1997).

Both definitions have been given to show that there are diverse schools of thoughts when it comes to LCA methodologies and the interpretation of their results thereof. This conclusion is supported by Heijungs and Guinee (2007) who state that LCA studies of waste management tend to produce quite diverging and even conflicting results. Even though this may be the case, important results can still be derived using LCA methods. For the purpose of this study, the most important result from LCA is the definition of the number of times that the same materials could be used in closed loop recycling before requiring disposal. Results from WRF (1995) show that:

a) Glass: Can be recycled indefinitely
b) Paper: Can be recycled four to five times before the fibres become too short to have viable strength
c) Plastic: Can be recycled many times, but will eventually require disposal
d) Cans: Can be recycled indefinitely without loss in quality

From these results, it can be seen that zero waste can be achieved for glass and cans using closed loop recycling, while paper and plastic require both open and closed loop recycling, but the residual waste will eventually require disposal. This conclusion underscores the importance of waste minimisation which can reduce the amount of residual waste generated.

2.5.4 Summary of Zero Waste Principles

Zero waste is a new philosophy and design principle for promoting waste reduction (GRRN, 2004). It focuses on managing resources and eliminating waste (TZC, 2004) rather than manage it (GRRN, 2004). This elimination of waste brings about considerable savings on landfill space, which makes zero waste an optimum environmental and sustainable tool (Zero Waste Kovalam, 2004). ZWK (2004) indicates that environmental progress will be achieved by just implicating change at one single point, 'where and how we empty our bins.' Experience has shown that the biggest obstacle in achieving zero waste is that there is generally very little economic incentive to implement it. "When we make it profitable to eliminate waste, everyone will scramble to do it," notes Christopher (2004). Another obstacle in achieving zero waste with regards to post-consumer waste is the state of waste management in both developed and developing countries.

2.6 Current waste management practices

In discussing waste management practices globally, delineation needs to be made between developed and developing nations.

2.6.1 Developed nations

According to WRC (1996) waste management in developed nations is generally characterised by four major trends: increasing use of sophisticated technology; emphasis on waste minimisation and recycling; greater responsibility and participation by householders in the waste management process; and ever more stringent legislation on all aspects of the waste management process. Furthermore, householders in developed nations enjoy a regular and efficient domestic waste collection service (WRC, 1996; Gamara and Salhofer, 2005). As such, householders participate in recycling and waste minimisation schemes, though their participation in such schemes is driven by different attitudes. It is suggested that waste minimisation behaviour is likely to be influenced by concern for the environment and the community and is likely to be inhibited by the perceptions of inconvenience and lack of time and knowledge (Tonglet et. al, 2004). Since waste minimisation plays a critical role in zero waste, the negative public attitudes on waste minimisation need to be addressed in order to enhance the viability of zero waste. Moreover, recycling also plays a key role in the zero waste approach. Understanding the public's motivation towards recycling can be beneficial in achieving zero waste. It is clear that the base for achieving zero waste in developed nations already exists. The same conclusion cannot be reached for developing countries.

2.6.2 Developing nations

Two contradictory perspectives on the state of waste management in developing countries are given by WRC (1996) and Onu (2000). According to WRC (1996), the major features of waste management in developing countries are: increasing need for community participation in the waste management process; extensive recovery, reuse and recycling of wastes; and the achievement of economic empowerment through the involvement with wastes. In contrast, Onu (2000) states that solid waste management in developing countries is characterised by many problems, which include: highly inefficient waste collection practices with variable levels of service; lack of environmental control systems; inadequate municipal services due to limited resources; indiscriminate dumping and littering and; a public with little or no awareness of waste management practices. These contradictory views highlight the lack of agreement among waste management researchers on the state of waste management in developing countries, but more importantly, they reflect the need to systemise research methodology so that comparisons and generalisations can be made about the state of waste management in developing countries. A more balanced perspective is given in the summary that follows.

In general, the organisation and planning of public waste collection service in developing countries is very rudimentary (Buenrostro and Bocco, 2003). Furthermore, this rudimentary state is reflected in the unknown quantity and type of solid wastes (SW) collected, the amount recycled and recovered, the inadequate selection of final disposal sites, as well as inefficient reutilisation and recycling programmes (Buenrostro and Bocco, 2003). In most cities, municipalities and towns in developing countries, solid waste management costs consume between 20% and 50% of municipal revenues (Altaf and

Deshazo, 1996; Henry et al., 2005; Alam et al., 2008), yet the waste collection service levels remain low with only between 50% and 70% of residents receiving services (Ali, 2005; Kaseva and Mbuligwe, 2005; Rathi, 2006; Sharholy, 2008) and most of the disposal being unsafe (Buenrostro and Bocco, 2003; Ali, 2005; Gamara and Salhofer, 2005). This preceding discussion is a summary of the state of waste management in developing countries. This state is likely to worsen due to continuing population growth and urbanisation in these countries (Altaf and Deshazo, 1996; DEAT, 2000b; South African Institute of Race Relations, 2002).

In order to substantiate these conclusions on the state of waste management in developing countries, three country case studies will be briefly analysed and compared with South Africa. These countries are: Brazil, India and Mexico. They were chosen on the basis of documented waste management data and on having similar economic (Brazil and Mexico) and social indicators (India) to South Africa. The comparative data for economic and social indicators is shown in Tables 2.1 and 2.2 respectively for all four countries, while the waste management data is shown in Table 2.3.

Table 2.1: Economic indicators in 2006 for developing countries (The World Factbook, 2007)

Country	**Nominal GDP (US$ million)**	**Population (thousand)**	**Nominal GDP per capita (US$)**	**Classification**
Brazil	1 067 706	186 800	9 108	Lower mid-income
India	886 867	1 169 016	3 757	Low income
Mexico	840 012	103 263	11 249	Upper mid-income
South Africa	255 155	48 577	12 796	Upper mid-income

Table 2.2: Social indicators in 2006 for developing countries (The World Factbook, 2007)

Country	Human Development Index (HDI)	Classification	Life expectancy (Years)	Literacy Rate (%)	Income Inequality (GINI)
Brazil	0.792	Medium	72	88	0.54
India	0.611	Medium	68	61	0.33
Mexico	0.821	High	75	90	0.50
South Africa	0.653	Medium	42	82	0.58

Table 2.3: Waste management indicators for developing countries [Arendse and Godfrey, 2002; Buenrostro & Bocco, 2003; Agarwal et al., 2004; Hugo, 2004; Mega-tech Inc., 2004; Ali, 2005; Engledow, 2005; Gamara & Salhofer, 2005; Kaseva & Mbuligwe, 2005; Munnich et al., 2005; The World Factbook, 2007; Hazra and Goel, 2008; Sharholy, 2008]

Country	MSW Generation (kg/cap/day)	Year	Urban Population Waste Collection Coverage (%)	Average Recycling Rate (%)	Disposal Rate in Sanitary Landfill (%)	CO_2 Emissions (kg/cap/yr)
Brazil	0.5 – 1.3	2002	71	12	28	1.69
India	0.2 – 0.5	2007	72	18	10	1.04
Mexico	0.4 – 1.0	2003	70	12	17	3.72
SA	0.2 – 2.7	2004	>90	32	<100	7.11

Table 2.1 and 2.2 show that developing countries are generally a mixture of strong economic indicators, as illustrated by the classification column in Table 2.1, and average to poor social indicators, as illustrated by the medium to high human development index (HDI) coupled with high ratios of income inequality (see Table 2.2). These then have a direct impact on waste management indicators shown in Table 2.3, which confirm the conclusions reached by Buenrostro and Bocco (2003) on waste collection service and by Buenrostro and Bocco (2003); Ali (2005); Gamara and Salhofer (2005) on unsafe disposal; the exception being the lack of data to substantiate the conclusion reached by Altaf and Deshazo (1996) on the effect of waste management costs on municipal revenues,

although Joseph (2006) tentatively supports that conclusion by stating that waste collection consumes almost the full budget of waste management in developing countries. Further analysis of Table 2.3 shows that although South Africa has poor social indicators compared with the other countries, it is able to provide for collection and safe disposal of generated waste whilst recycling a higher fraction of the generated waste compared with the other countries. This will be elaborated on in Section 2.7 where a thorough analysis of waste management in SA will be undertaken.

Compared with developed nations, developing countries face a larger challenge in the move towards zero waste. The major challenge is addressing poor level of service, which is exacerbated by lack of resources, lack of expertise among waste practitioners, lack of political will, inadequate legislation and lack of enforcement of existing legislation (Fourie, 2006). Adopting proper waste management practices such as an all encompassing waste collection service will improve householders' perceptions about waste and its impact on their quality of life. Educational programmes can then be used to enhance these positive perceptions, starting with waste minimisation and recycling, right through to zero waste.

This brief synopsis of the waste management situation in developing countries serves as a background to the introduction of zero waste in these countries. It shows that the achievement of zero waste in developing countries will require efforts from waste management authorities and households. The authorities will need to streamline waste management services, beginning with the provision of basic waste collection services from all households. Once this has been achieved, citizens must then be educated on an on-going basis about waste minimisation practices: reduction, reuse and recycling with at-source separation. Since attitudes on recycling and waste minimisation may be non-existent, especially in peripheral urban areas and rural areas, education programmes will need to be undertaken to establish them. The aim of these educational programmes will be to achieve zero waste within households.

2.7 Waste management in South Africa

In this section, an overview of waste management in SA will be undertaken and major components of the framework will be discussed. These include legislation affecting waste management, which includes waste minimisation and recycling, as well as the potential to achieve zero waste in SA. For a comprehensive, but slightly dated, review of waste management in the country, WRC (1996) report should be consulted. More extensive and updated reports on the waste management situation in South Africa have been produced by the Department of Environmental Affairs and Tourism (DEAT 1999; 1999b; 2000; 2000a; 2000b; 2000c; 2005).

2.7.1 Waste service coverage

From the discussion in Section 2.6, SA is classified as a developing country, and as such, the waste management practices discussed in that section are applicable. Government Digest (2003) indicates that environmentally and socially unacceptable practices characterise many aspects of waste management, particularly in rural areas where services are often non-existent. Furthermore, in many of those urban communities that have always had poor levels of service, those services collapsed as a result of non-payment and poor financial planning (DEAT, 2000; Government Digest, 2003). Although this may be the case, there are urban areas within the country which have the same level of service as that in developed nations in terms of waste collection coverage. This disparity in service coverage between different communities within the same locality is a characteristic of waste management practices in South Africa. The disparity in service delivery gave rise to the following waste management objectives (United Nations Division for Sustainable Development, 2007): "minimising waste production; maximising environmentally sound reuse and recycling; promoting environmentally sound waste disposal and treatment; and extending waste service coverage to all generators of waste".

Currently, municipalities are trying to address the lack of waste services in low income and informal areas through the use of community based contractors who collect waste in and around localities where they stay (Marshall, 2005; McKinnon, 2006). However, some municipalities find it difficult to maintain this level of service, let alone to increase it to levels required by legislation, due to lack of financial resources needed to maintain these services (Wates and Bredenhann, 2002; Hoon et al., 2006). Furthermore, the service charges levied by municipalities do not reflect the true cost of the service and this directly affects the quality and economic sustainability of the service being provided (DEAT, 2000c). Moreover, these municipalities also lack adequately trained/qualified human resources required to maintain and upgrade the levels of waste management services, and waste management is often an "add-on" function to existing posts in the municipality (Wiechers et al., 2002; Hoon et al., 2006). This lack of both financial and human resources is further strained by the integration of previously unserviced areas into already overburdened municipal structures (Poswa, 2002). In summary, waste service levels will remain inequitable until issues pertaining to financial and human resources within municipalities have been addressed. This is despite the enactment of the Local Municipal Systems Act (Act 117 of 1998) that requires municipalities to provide waste management services equitably within their areas of responsibility. The details of this piece of legislation will be discussed further in Section 2.7.5, whereas the next section focuses on MSW generation rates in South Africa.

2.7.2 Waste generation

Even though it is a legal requirement, reporting of annual waste generation figures for South Africa is not undertaken (DEAT, 2000c). DEAT (2000c) further reports that attempts have been made by DWAF (Department of Water Affairs and Forestry) and DEAT to quantify waste generation. The results of this exercise are given in Table 2.4. It can be seen from Table 2.4 that MSW generation accounts for a small fraction of the total waste generated. Furthermore, there is a decrease in MSW generation between the two periods reported. This decrease is highly unlikely given that other sources estimate MSW generation at about five times of the figure in Table 2.4 for the same period (Arendse and Godfrey, 2002; Mpumalanga Provincial Government, 2003). Overall, this lack of agreement between different reports is an indication that generalised MSW generation figures for South Africa should be viewed with caution. However, this lack of data can be overcome using waste generation figures supplied by different municipalities, and aggregating that data for average MSW generation rates. An example of municipal data is given in Table 2.5 for the City of Cape Town, where the data reported is compiled from disposal records at landfill sites. Although this data is available from some Metropolitan Municipalities, its availability nationally is limited (Arendse and Godfrey, 2002), especially with regard to rural areas. The data shows that MSW generation in South Africa ranges between 0.2 – 2.7 kg/capita/day as summarised in Table 2.3.

Table 2.4: Waste generation rates in South Africa (million tons/annum) [Wates and Bredenhann, 2002]

Waste Stream	1992 (CSIR study)	1997 (DWAF)
Mining	378	468.2
Industrial	23	16.3
Power Generation	20	20.6
Agriculture and forestry	20	20*
Domestic and Trade (MSW)	15	8.2
Sewage and Sludge	12	0.3
Total	**468**	**533.6**

* Assumed from CSIR study

Table 2.5: Annual tonnages of waste received at landfill sites around the City of Cape Town (thousand tons/annum) [Engledow, 2005]

Annual Tonnages (thousand tons/annum)						
Municipal Landfill Sites	**1997/1998**	**1998/1999**	**1999/2000**	**2000/2001**	**2001/2002**	**2002/20003**
Vissershok**	328	289	239	273	302	317
Coastal Park	222	235	298	338	359	377
Swartklip	185	183	221	234	241	253
Belville	329	392	290	309	300	315
Brackenfell	79	130	203	222	234	246
Faure	166	229	212	220	201	211
Total	**1309**	**1458**	**1493**	**1596**	**1637**	**1719**
% Annual Increase		**10.2**	**2.3**	**6.5**	**2.5**	**4.8**

** Receives substantial amount of de-listed waste from other provinces in South Africa

From Table 2.5 it can be seen that there is an annual increase in the total waste disposed in City of Cape Town, which is a clear indication that waste generation is increasing. This annual increase is also an indication that the MSW figures reported in Table 2.4 could be incorrect.

2.7.3 Waste collection and transportation

As discussed in Section 2.7.1, household waste management service levels vary from non-existent to fully-fledged. In unserviced and poorly serviced areas, there is a lack of structured or standardised collection systems, which results in waste being dumped indiscriminately in the locality (DEAT, 1999b). In serviced areas, collection is carried out using either a kerbside system or a communal skips (DEAT, 2000). While kerbside collection provides the highest level of service for collection, it has a problem in the informal recyclers open the bags before they are collected, which can produce litter (Engledow, 2005; Fiehn, 2007). Integration of these recyclers into formal recycling schemes can help alleviate this problem (Engledow, 2005; Fiehn, 2007). The main problem associated with using skips for waste collection is that the distance between the skip and waste generation points is considerable and as a result, the waste is either dumped illegally or burned or becomes litter in the area where it is generated (DEAT, 2000). In order to remedy this problem, community based service providers have been appointed to collect waste door-to-door and transport it to a central collection in the area, examples being Marina da Gama in Cape Town, Nazareth in Durban and Duncan Village in East London (DEAT, 2000; Morkel, 2002; McKinnon, 2006; Matete and Trois, 2008 and Lucas, 2008). The use of community service providers has resulted in improved collection services to the communities being served (Morkel, 2002; McKinnon, 2006).

The collection and transportation of MSW in South Africa is the responsibility of municipalities (Republic of South Africa, 2000). The types of vehicles used vary between municipalities, and is dependent mainly of the financial resources available to the municipality. For example, metropolitan municipalities such as Cape Town, Durban and Johannesburg use rear end loaders and rota-press trucks to transport waste form kerbside collection points to landfill sites (Mega-Tech Inc, 2004; SKC, 2004). Skip collection from low level services areas is also carried out using hooklift trucks (SKC, 2004). Where collection is carried out by community based contractors, which is usually the case in low income urban areas, light duty vehicles are used to transport waste to landfill sites (Marshall, 2005). In rural municipalities, which generally have less financial resources than metropolitan municipalities, tractor-trailer has wide application in waste collection and disposal (Neethling et al., 2006). Where considerable transportation distances are involved, refuse transfer stations (RTS) are utilized in transferring waste from low capacity to high capacity vehicles for bulk transportation of waste to landfills (Novella, 2002; SKC, 2004; Stotko, 2006). Although waste collection and transportation costs are not readily available for South Africa, international experience shows that this costs account for about 70 – 85% of waste budgets in both developed and developing countries (Davis and Cornwell, 1998; Hazra and Goel, 2008; Sharholy, 2008).

2.7.4 Waste disposal

The primary and predominant way of dealing with MSW generated within South African municipal areas is to dispose of it in landfill sites (DEAT, 2000c; Stotko, 2006). Both MSW and certain types of industrial waste are disposed of in general waste landfill sites which are operated by municipalities (DEAT, 2000c). Disposal of waste in landfills is considered to be the most economical method compared with other waste management options (DEAT, 2000c). However, Stotko (2006) argues that this is not necessarily true since landfilling costs do not consider external costs. When these costs, examples being air pollution from landfill activities and green house gas emissions that contribute to global warming, are taken into consideration, the landfill option is less cost effective than other waste management options such as recycling (Stotko, 2006). This conclusion is significant for waste management in South Africa as it suggests that landfilling is no longer the best practicable environmental option for dealing with waste. The White Paper on Integrated Pollution and Waste Management (Republic of South Africa, 2000b), which sets the direction for waste legislation, asserts this fact.

2.7.5 Legislation

Environmental legislation is defined as "a set of legal principles, acts, regulations, directives, and laws, influencing both the environment and the inhabitants of each country" (Glavic and Lukman, 2007). Until the White paper on integrated pollution and waste management (Republic of South Africa, 2000b) was published towards the end of 2002, SA did not have a single comprehensive national statute dealing with waste management and pollution control (DEAT, 1996; Government Digest, 2003). At least 37 national statutes, administered by numerous government departments had bearing on land related waste generation and pollution (DEAT, 1996). As summarised in Godfrey and Dambuza (2002) and Government Digest (2003), waste management legislation was fragmented and focused waste disposal, with a resultant lack of control in all aspects of waste management. In addition, a lack of capacity meant that the enforcement of existing legislation was also frequently unfocused (Government Digest, 2003). The purpose of the White paper is to remedy this existing situation (Republic of South Africa, 2000b).

With specific reference to waste minimisation and recycling, the White paper (Republic of South Africa, 2000b) has set the following goals:

a) To adopt measures (in close cooperation with the private sector) aimed at facilitating and coordinating widespread implementation of existing successful waste minimisation and recycling initiatives. Specific outcomes include: developing mechanisms to set targets for minimising waste and pollution at source; identifying all successful existing recycling initiatives and implementing measures to ensure their on-going success and viability; separation and recovery of resources as early as possible in waste generating processes in both commercial and domestic sectors; resource recovery at waste transfer stations, waste treatment facilities and waste disposal sites; and subsidising recycling campaigns in order to make them economically viable.

b) Developing and implementing a program for disseminating information by DEAT on the techniques, opportunities and benefits associated with cleaner production, waste minimisation and recycling. Specific outcomes include: establishment of waste minimisation and recycling centres; dissemination of information on waste minimisation by developing a directory of case studies and sector specific guides; implementation of demonstration projects; promotion of information and awareness campaigns about waste minimisation and recycling by DEAT, in collaboration with local government; and amending educational curricular to reflect cleaner production, waste minimisation and recycling approaches to waste management

c) The introduction of economic instruments and incentives to promote recycling, including for example the possible introduction of levies on specific products or materials with high environmental impacts. The economic instruments would include the development of appropriate pricing strategies for waste and waste resources

d) For waste generators to be given sufficient inducement to recycle and minimise waste, it is essential that there should be an appropriate legal and policy framework comprising both legal sanctions and financial incentives

It is within this legal framework that waste minimisation and recycling initiatives should be implemented. However, local authorities are under extreme pressure to provide basic services to all households as required by the Local Government Municipal Systems Act (Republic of South Africa, 2000), hence recycling and waste minimisation needs to be implemented at little or no additional cost to the ratepayer in order to ensure its success (Davies et al, 2000).

2.7.6 Recycling and waste minimisation

Despite the lack of legislation to drive recycling (Arendse and Godfrey, 2002), there is a relatively high level of recycling practiced (Borland et al, 2000). WRC (1996) cites Lombard (1994) stating that the "low technology recycling industry in South Africa is alive and well." The level of recycling is influenced by socio-economic and demographic factors (DEAT, 2000b). DEAT (2000b) and Liebenberg (2007) further add that monetary incentives are of prime importance in the lower socio-economic income groups while environmental concerns drive recycling behaviour in the middle to upper income groups.

Current methods of recycling include scavenging, drop-off centres and buy-back centres. Scavenging (informal recycling) takes place on landfill sites or transfer stations with unacceptable working conditions and achieves less than 1% reduction in the waste stream (des Ligneris, 2000; Ridl, 2003). At present, scavenging is no longer permitted on some landfill sites, while it is permitted and formalized on others, but allowed to take place under very strict conditions. Drop-off centres, which are operated by municipalities and used by the general public, also achieve less than 1% reduction (des Ligneris, 2000 and Ridl, 2003). With buy-back centres, recyclable waste is brought manually, usually by scavengers and also contributes to a negligible waste reduction (des Ligneris, 2000). The reduction figures for drop-off and buy-back centres should be treated with caution as they cannot be confirmed by local waste management authorities or other independent reports.

Much of the recycling in South Africa is attributed to the recycling activities of the packaging industry (DEAT, 1999). The main recycling activities are the following (DEAT, 1999):

a) Paper and fibre recycling, with four large paper companies (Sappi, Mondi, Nampak and Swazi paper) utilising waste paper products.
b) Glass is collected for recycling mainly by Consol glass via collection depots (bottle banks) or containers at individual businesses. It is collected as either cullet (crushed glass), broken glass or as whole bottles, which may be cleaned and reused.
c) Steel beverage cans and aluminium cans are recycled mainly through Collect-a-Can. Recycled aluminium can fetch a high price, but is not widely used in South Africa.
d) Most plastic that is recycled, mainly by Nampak, is recovered from the general waste stream. The economics of plastics recycling are determined by labour costs for collection, sorting and processing, as well as transport costs and electricity and water consumption costs for washing and processing the recovered materials.

The packaging industry plays a significant role not only in directly recycling the material, but also in co-ordinating the collection of the recyclable material through local agents (DEAT, 2000b). The results of this effort by the industry are shown in Table 2.6. Table 2.6 gives an indication of the recycling statistics for SA according to the packaging industry. The first point worth highlighting from Table 2.6 is that although the average recycling rate for recyclables increased over the period shown in the table, the rates for the individual recyclable materials varied considerably. This variation is indicative of the market-driven nature of the recycling industry in the absence of legislation enforced recycling. According to DEAT (2000b), the lack of markets for the recyclables can be solved by finding the balance between securing the supply of recyclable materials and promoting the demand for products that are made from these materials, while appraising the social, environmental and economic impacts of recycling. Secondly, there is a significant jump in the volume of paper and cardboard recycled in 2000 and 2002. In the absence of independent data to verify these figures, it can be concluded that the reporting of recycling statistics is not verifiable; hence the data reported in Table 2.6 should be treated with caution.

Table 2.6: Recycling statistics for South Africa in Percentage (Lombard, 1997 & PACSA, 2002)

Category	**1984**	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2002**	**Average**
Paper & Board	54.3	29.0	28.4	38.0	28.4	38.0	88.7	102.1	**50.9**
Metal - Tin plate	11.6	21.0	26.3	51.0	26.3	51.0	46.0	35.1	**33.5**
- Aluminium	11.6	36.0	29.6	50.0	29.6	50.0	46.0	35.1	**36.0**
Plastics	21.5	11.0	14.8	17.0	14.8	17.0	28.6	31.9	**19.6**
Glass	13.7	14.0	22.4	17.6	22.4	17.6	20.2	33.3	**20.2**
Average	22.6	22.2	24.3	34.7	24.3	34.7	45.9	47.5	**32.0**

Typical system costs for recycling in Durban were compiled by Beningfield (2002) for paper, cardboard, plastic (polyethylene terephthalate – PET), glass and cans. Typical glass recycling costs incurred by the generator, the collector and the processor are shown in Table 2.7 (Typical recycling costs for paper, plastic and cans are attached in Appendix B). It can be seen from the table that transportation costs accounts for the biggest share of the overall costs. This is due to the fact that there are no glass processing plants in Durban and as a results, all glass collected for recycling has to be transported to Johannesburg for processing. Transportation of recyclables to distant processing plants is a common theme in the recycling industry in South Africa, although its significance is variable for different recyclables and geographical locations (Beningfield, 2002). Overall, collection costs for paper, glass, plastics and cans are similar, while transportation costs and processing costs are different due to volumes transported, market conditions and production processes for the different materials.

Apart from the efforts of the private recycling sector, no large scale organized at-source recycling of general wastes takes place in South Africa (DEAT, 2000b). In terms of household waste, a number of attempts at kerbside recycling in Durban and Johannesburg have failed due to public apathy (DEAT, 2000b), while mixed waste recycling is characterised by some significant failed ventures (WRC, 1996; DEAT, 2000b): Robinson Deep Waste flow plant in Johannesburg, Resource Recycling Plant in Randburg and Tempo Recycling plant in Durban, a labour intensive initiative. Although the plants worked from a mechanical point of view, their failure has been attributed to an overestimation of the value of recoverable materials, unrealistic requirements of the municipalities involved, a down-turn in the economy at the time the projects were launched and decreases in the value of recycled materials (DEAT, 2000b). Literature shows that this phenomenon is not

Table 2.7: Typical direct costs incurred to send glass to the processor (Beningfield, 2002)

Direct Costs	**Rates**
Generator	
- Labour to separate grades of glass	R 70.00 per ton
@R7.00 / hr ; 100 kg/hr	
Collector	
- Transport in SKIP vehicle within 50 km radius	R 42.86 per ton [a]
- Transport in 7 ton vehicle within 50 km radius	R 40.00 per ton [b]
- Payment to generator for separated glass	R 60.00 per ton [a]
- Payment to generator for mixed glass	R 20.00 per ton [b]
- Long-haul vehicle in super-link vehicle to Johannesburg	R 132.35 per ton [a & b]
Processor	
- Payment to collector for separated glass	R 234.00 per ton plus
	75% of the long-haul transport
- Payment to collector for mixed glass	R 150.00 per ton plus
	75% of the long-haul transport

a For post producer generators

b For post consumer generators

restricted to South Africa only. In Rio de Janeiro, Brazil, 15 plants for recyclables sorting and composting of waste built at a cost of US$50 million (~ R350 million at 2007 prices) have never gone into operation or were closed shortly after they were commissioned (Munnich et al., 2006). Although the reason for the failure of these plants have not been given, it is clear that recycling in developing countries using capital intensive plants is not advisable.

While recycling has been the focus in this section on waste management in South Africa, it is important to note that waste minimisation in South Africa is understood in terms of production process waste rather than in terms of post-consumer waste as illustrated by Figure 2.4 and the discussion of waste minimisation in Section 2.3. As such, there is little or no data on the application of waste minimisation within post-consumer waste management at household level. This study is an attempt to fill that gap in anticipation of fulfilling the goals of the Polokwane Declaration on Waste Management (DEAT, 2001).

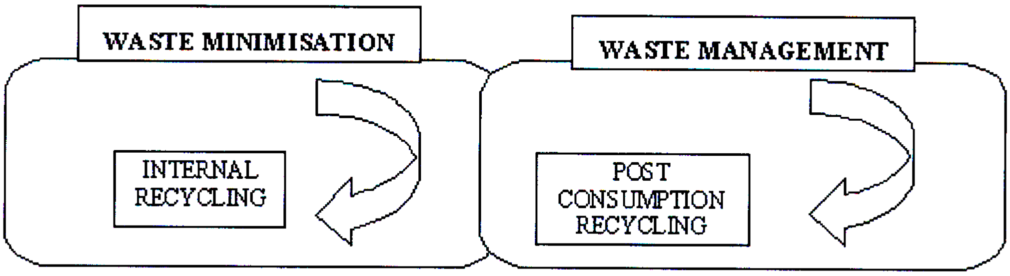

Figure 2.4: This diagram emphasises the distinction between "internal recycling" (a technique for waste minimisation) and "external recycling" (the third level on the waste management hierarchy) (DEAT, 1999)

2.7.7 Education

As discussed in Section 2.6.2, environmental education is the key to enacting zero waste paradigm shift among households. In this section, current environmental education status will be discussed. Environmental education in South Africa is administered by the Department of Environmental Affairs and Tourism using the National Waste Management Strategy (NWMS) as launched by the Department in 1999 (DEAT, 1999b). The strategy is aimed at building the culture of responsibility in communities with regard to Integrated Pollution and Waste Management, with the ultimate goal of sensitising communities, encouraging them to think creatively about solving the problems of waste and motivating them to establish projects, which will alleviate pollution and waste problems and thereby improve the quality of life of the community (DEAT, 1999b). This initiative has been supplemented by promotion of environmental awareness in local municipalities, examples being the Fairest Cape Association in Cape Town and the Waste Minimisation and Recycling division of Durban Solid Waste in Durban (DEAT, 2000b). The educational initiative has also been supplemented by the National Cleanest Town Competition (DEAT, 2000b). The private recycling sector also plays its role through education and public awareness campaigns aimed at schools and local communities (DEAT, 2000b). The Institute of Waste Management of Southern Africa (IWM-SA) also has a major function/dedicated portfolio on education with regard top waste management. The impact of all these campaigns on the waste generation and recycling rates is unknown at present.

2.7.8 Zero waste

The existing waste management situation in South Africa is summarised in DEAT (2000b): waste management is currently characterised by a range of problems, including *inter alia* a lack of direction concerning waste recycling. This is the situation that forms the background to the application of zero waste. It is interesting to note that Dohrman and Naidoo (2003) have concluded that zero waste is an unattainable goal and is not applicable to South Africa. The major aim of this thesis is to try to show that zero waste is indeed an attainable goal. An example that this is possible in South Africa is illustrated by the waste reduction achievements of the Century City Shopping Centre in Cape Town.

"The Century City "Canal Walk" shopping centre in Cape Town is Africa's second largest shopping centre with over 460 shops and 45 restaurants. The centre's tenants implemented a wet/dry source-separation system and have reduced disposal to about 5700 kg/day from 15000 kg/ day, a 62% reduction. Furthermore, the centre saved R594,000 in capital costs by downscaling the number and size of trash compactors, saved approximately R20,000 every month in reduced disposal costs, and has created 28 jobs in its 'In-house Waste Collection/Separation' service. Information regarding remaining landfill airspace, anticipated disposal cost increases, possible legal changes towards 'polluter pays' principles, and specialised waste reduction/management service advice convinced centre management to take action" (Dittke, 2007).

2.8 Summary

In this chapter, a general review of post-consumer waste management situation globally and in South Africa has been undertaken. Waste management principles, including the definition of waste have been discussed. It has been shown waste reduction techniques as envisioned in the waste hierarchy are not being applied systematically to address the increasing volumes of waste arising from households. Furthermore, it has also been shown that recycling alone cannot effectively reduce the amount of waste being generated by households. Rather, a combination of waste minimisation and recycling, theoretically at least, should be able to reduce the amount of waste going to landfill. This conclusion is relevant to waste management systems in both developed and developing countries. While recycling behaviour of households has been well researched in developed countries and household recycling schemes have been subsidised, research and application of waste minimisation has lagged behind. This situation is even more acute in developing nations where recycling schemes are carried out on an ad-hoc basis due to lack of funds and expertise by Municipal Authorities. It is within this context that zero waste will need to be applied in South Africa. The conceptual model needed to test the applicability of zero waste to post-consumer waste management systems will be developed in the next chapter.

CHAPTER 3

3. DEVELOPMENT OF A CONCEPTUAL ZERO WASTE MODEL

3.1 Introduction

The development of a conceptual zero waste model (ZWM) for application to the post-consumer waste fractions identified in Section 2.2.1.2, which follows on from the literature review carried out in Chapter 2, will be discussed in this chapter. The ZWM will be developed by applying sustainability criteria, in conjunction with the waste hierarchy identified in Section 2.2.3, to the existing waste management systems. As established by Rathi (2006), there is a need to work towards sustainable waste management systems in developing countries, which requires environmental, institutional, economical and social sustainability. These sustainability criteria, along with the overarching concept of sustainability, will be defined in this chapter.

The chapter consists of five sections. Section 3.2 gives a summary of waste management principles, especially the waste hierarchy, while the concept of sustainability and its criteria will be discussed in Section 3.3. Section 3.4 will merge the waste hierarchy with the sustainability criteria into the ZWM, while the context for the application of the ZWM will be discussed in Section 3.5. A summary of the chapter will be given in Section 3.6.

3.2 Application of waste management hierarchy

From Section 2.2.3 in Chapter 2, it can be seen that although the waste hierarchy has been adopted into waste management, it is not being applied fully to post-consumer waste as shown by the levels recycling being achieved and the lack of waste minimisation behaviour among households. The negation of waste minimisation behaviour and low recycling rates means that the objectives of waste management systems identified by Robinson (1996) in Section 2.2.3 are not being fulfilled, hence a conclusion can be made that post-consumer waste management strategies for communities globally are unsustainable. On the supply side, this situation can be remedied by application of extended producer responsibility (EPR). Besides falling outside the scope of this research, it has been shown in Section 2.4.3 that the use of EPR to curb increasing waste generation rates is problematic since it is a legislative instrument. This means that the unsustainability of waste management systems can probably be resolved by studying the demand-side of post-consumer waste: the active involvement of households in the management of the waste generated. As stated by Ishizaka and Tanaka (2003), the public's positive participation and cooperation is essential in establishing MSW management systems that are geared towards sustainability. The public can get involved in these systems through waste minimisation and recycling, with at-source separation, as discussed in Sections 2.3 and 2.4 respectively.

In developed countries, the US, Germany and the UK for example, application of the hierarchy has produced a post-consumer waste management system that is depicted in Figure 3.1. Figure 3.1 shows that this system is reliant on recycling, energy recovery and composting, with landfilling as a final waste management option. Furthermore, the system is technology based, especially for energy recovery and composting of non-recyclable waste, while households focus on source-separation of recyclable waste. It is important to note that despite the participation of households in recycling, those households do not engage in waste minimisation practices. This lack of waste minimisation behaviour shows that the system is not completely sustainable as the highest level of the hierarchy, namely waste minimisation, is not being implemented.

The use of technology is less prevalent in waste management systems in developing countries as depicted in Figure 3.2. From Figure 3.2, it can be seen that household waste is collected by designated collectors and transported to MRFs where the recyclables are separated from the rest of the waste. The recyclables are then sold in the markets, while organics are composted, and the residual waste is disposed of in landfills. As shown by the South African case study in Chapter 2, MRFs have fared badly in developing countries and source separation of recyclable waste is carried out on an ad-hoc basis. Also, the composting of putriscible waste is less technology intensive than in developed countries. Moreover, waste minimisation behaviour is not being practiced by households; hence waste systems in developing countries are less sustainable than those in developed countries.

The preceding discussion has shown that current waste management systems are unsustainable given the lack of application of waste minimisation as warranted by the waste hierarchy and the limited impact of recycling in reducing waste generation rates. Both these techniques are foundational to the sustainability of post-consumer waste management systems. The issue of sustainability will be discussed in the next section as a foundation for the conceptual zero waste model that will be proposed in Section 3.4.

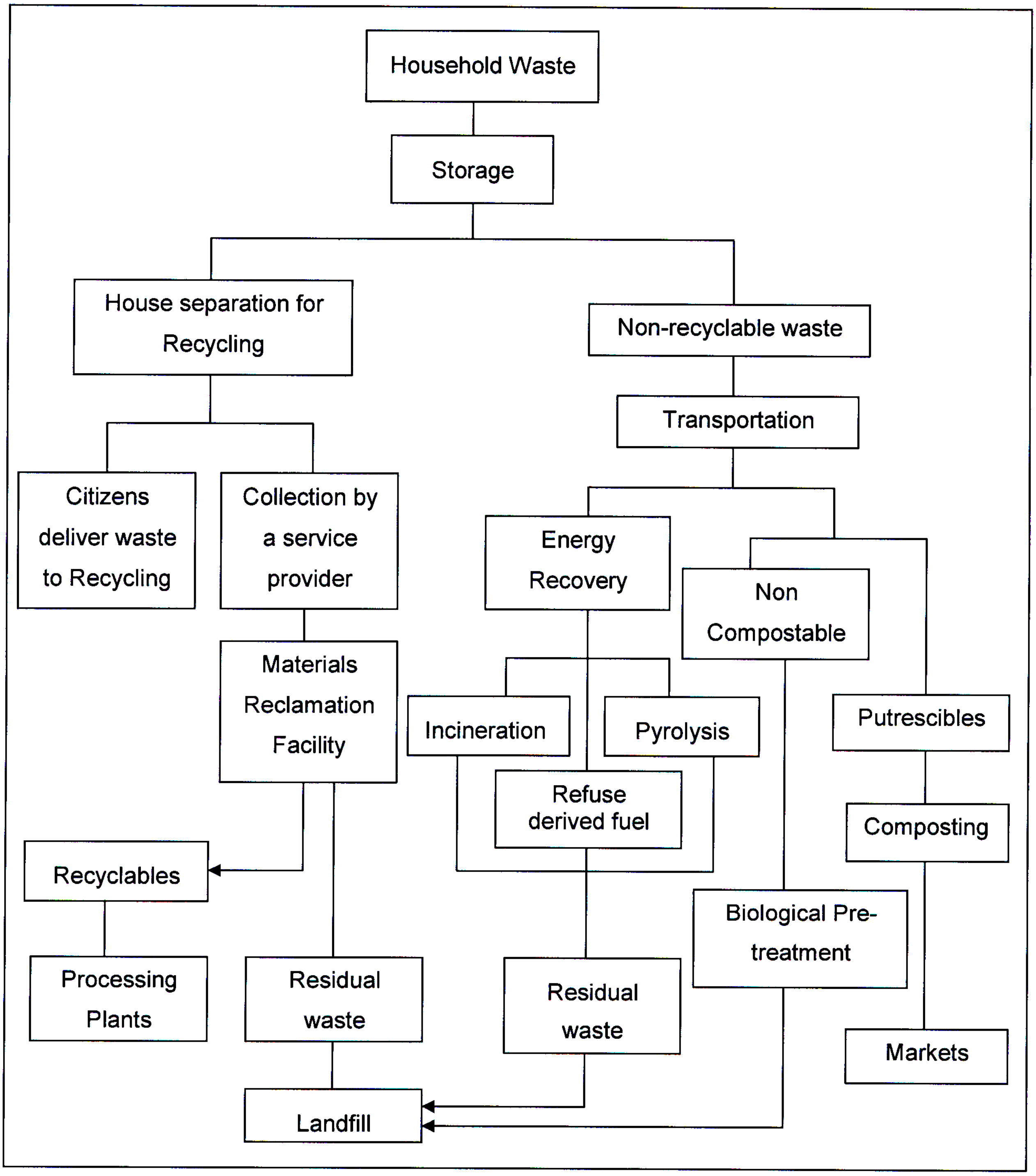

Figure 3.1: Material flow diagram for a typical household waste management system in developed countries (Adapted and modified from Davis and Cornwell, 1998; Najm and El-Fadel, 2004; Bovea and Powell, 2006; Banar et al., 2008)

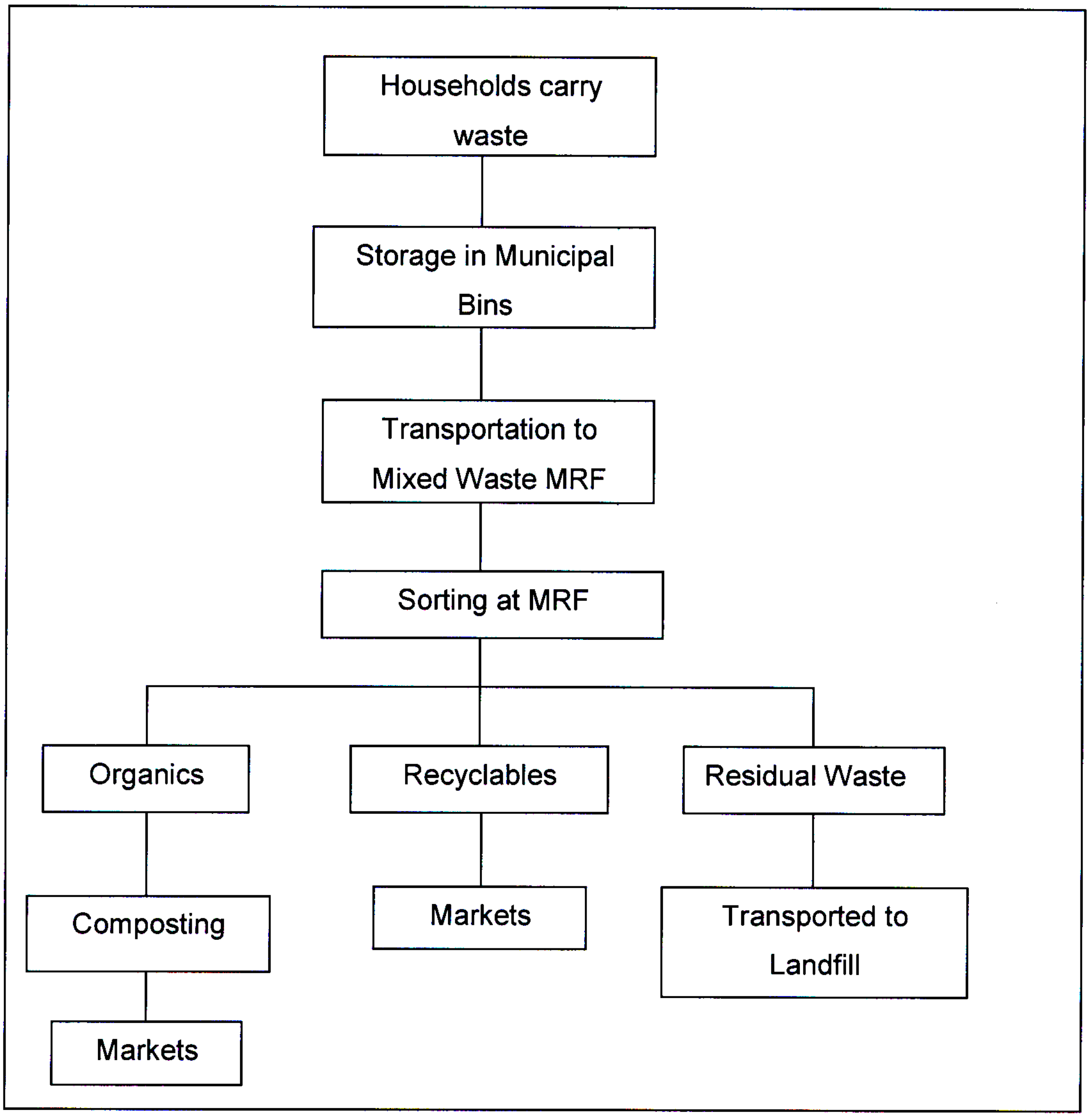

Figure 3.2: Material flow diagram for a typical household waste management system in developing countries (Adapted and modified from Rathi, 2006)

3.3 Sustainability

Sustainability is "a fluid and emergent concept that has become the principal aim of environmental policy and has for many managers become an appropriate vision for the future" (Macris and Georgakellos, 2006). It is intended as "a means of configuring human activity so that society and the economy are able to meet present needs, while preserving biodiversity and natural ecosystems, and planning and acting for the ability to maintain these ideals in the long term" (Wikipedia, 2006). For waste management systems, sustainability is an integrated framework required to transit from waste generation, storage, handling, collection, treatment and disposal into waste minimisation and recycling (Joseph, 2006; Glavic and Lukman, 2007), and ultimately zero waste. Furthermore, sustainability provides a comprehensive framework for addressing the problems of managing MSW in resource constrained developing countries where the quality of such services are poor and costs are high, often with no means of recovering the costs (Joseph, 2006). The sustainability framework includes economic, environmental and social dimensions (Bjorklund and Finnveden, 2005) (see Figure 3.3). The importance of sustainability of waste management systems is summarised by Morrissey and Browne (2004) who emphasise that for a waste management system to be sustainable, it needs to be "environmentally effective", "economically affordable" and "socially acceptable". Institutional sustainability needs to be added to this list as post-consumer waste management systems are usually the responsibility of municipalities in developing countries (DEAT, 2000d; Buenrostro and Bocco, 2003; Kaseva and Mbuligwe, 2005 and Sharholy, 2008). The effect of each dimension on a MSW management system will be elaborated on in the sections that follow.

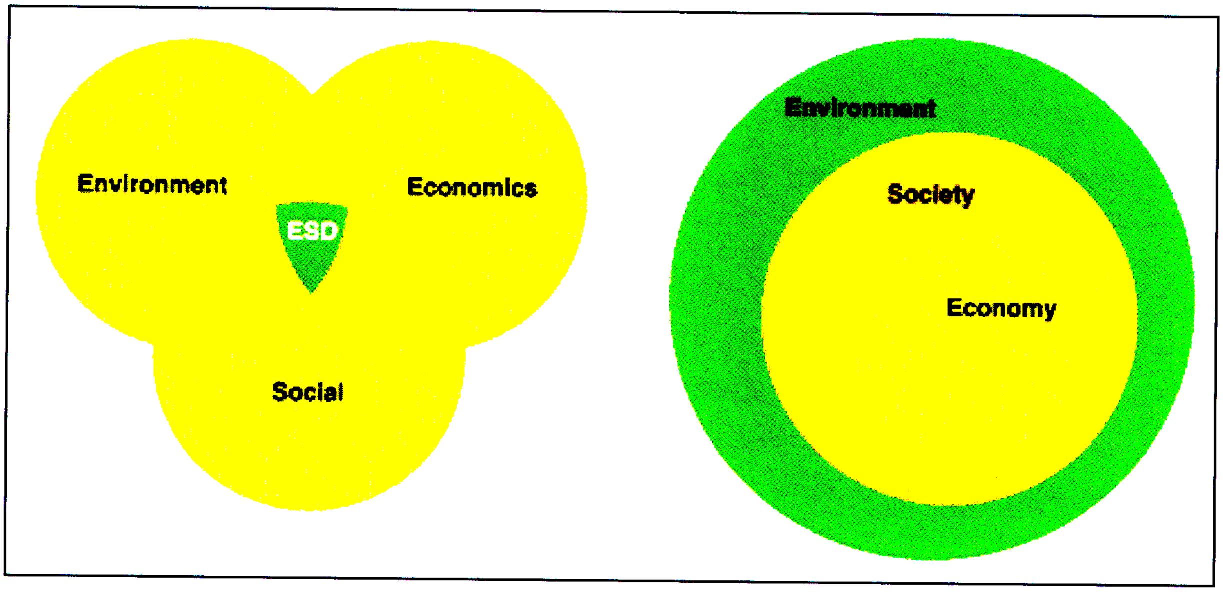

Figure 3.3: Interaction of the sustainability criteria (shown on the left) and the dependence of the economy and society on the environment (shown on the right)
(Source: http://sustainability.uoregon.edu/search/about_us.php)

3.3.1 Environmental dimension

In many respects, achieving ecological or environmental sustainability is closely linked to the manner in which households deal with the generated waste (Klang et al., 2003). As shown by Bjorklund and Finnveden (2005) in a study involving 40 cases in developed countries, the global warming potential (GWP) of recycling the post-consumer fractions identified in Section 2.2.2.2 is lower than landfilling, which is in turn lower than incineration. This result indicates that the environmental impact of recycling the identified fractions is lower than that of landfilling and incineration. Indeed this was the conclusion that was reached in the discussion in Section 2.4.5 on the benefits of recycling the same fractions. Furthermore, the energy conservation achieved in recycling most of the fractions, compared with the use of virgin materials, also renders recycling more environmentally sustainable than the two waste disposal options (Waste Watch, 1999). As also mentioned in Section 2.4.1, at-source separation of the recyclables by households further enhances the environmental benefits of recycling; hence recycling with at-source separation is even more environmentally sustainable than the aforementioned waste management options of landfilling and incineration. Waste minimisation increases sustainability by reducing the total amount of waste that would need to be separated for recycling and ultimately the amount of waste that would need disposal. As stated by Boyle (1989, cited in Morrissey and Brown, 2004), reducing the amount of waste ultimately requiring disposal at the point of generation is the most rational and cleanest means of solid waste management.

This preceding discussion shows that waste minimisation and recycling need to be included in the zero waste framework being developed. However, as shown in Figure 3.3, environmental sustainability is only one consideration in the sustainability framework; economic sustainability of waste systems using waste minimisation and recycling needs to be taken into consideration as well.

3.3.2 Economic dimension

Traditionally, waste management systems have aimed at dealing with waste in the most economically efficient way (Sonesson et al., 2000), and landfilling provided such a solution. However, after the Rio Earth Summit (1992) and the adoption of Agenda 21 principles, landfilling became the least desirable option for dealing with waste, even though it was still the most cost effective. The change in priority was brought about by the adoption of the Waste Hierarchy as discussed in Section 2.2.3. Furthermore, (Brisson, 1997) has shown that landfilling was the most economical way of dealing with waste because the economic tools used in assessment, cost benefit analysis (CBA) for example, did not consider the full environmental and social costs of landfilling. This lack of full cost accounting has been exacerbated by providing waste management services to the household sector unpriced (Goddard, 1995). This means that households have not paid directly for the waste they generate, and as result cannot see the impact of their consumption choices and the unsustainable rate of depletion of available landfill space.

In order to solve the problems associated with increasing waste generation rates as discussed in Section 1.1, recycling was introduced as a means of reducing the amount of waste needing disposal. Despite the environmental benefits of recycling, it has been shown by Goddard (1995) and Greyson (2007) that recycling is not economically sustainable. Although unsustainable, recycling could be employed as part of an economically sustainable waste management system by employing other economic instruments. These instruments include pay-as-you-throw, reduction of tax subsidies on virgin material extraction and waste minimisation at source by households. On the demand-side aspects of waste management, which is the focus of this thesis, only two of the proposed solutions could be possibly employed: pay as you throw and waste minimisation.

Pay as you throw (PAYT), also known as unit pricing or variable-rate pricing (Karagiannidis et al., 2006), is a term used to describe an equitable approach to household waste management whereby the fee charged for waste collection directly relates to the quantity of waste generated for disposal (Price, 2001). Charging a unit fee for residential solid waste collection provides two incentives for households: less waste generated for disposal and; stimulation of recycling and waste minimisation (Miranda and Aldy, 1998). In fact, PAYT is a long term solution intended to complement recycling strategies by extrinsically encouraging participation and also to initiate moves up the waste hierarchy towards waste minimisation (Price, 2001). However, Miranda and Aldy (1998) also show that PAYT may encourage additional littering and other forms of undesirable diversion. In developed countries, this negative impact of PAYT is offset by proper enforcement of regulations and environmental awareness by waste generators as discussed in Section 2.6.1, hence the success of the system (Goddard, 1995; Miranda and Aldy, 1998; Price, 2001). Yet, as discussed in Section 2.4.1, instruments of public action that are applicable in developed countries may not be readily applicable to developing countries, thus rendering the use of PAYT inappropriate for developing country conditions. Furthermore, given that waste collection service coverage in developing countries is less than optimal (see Table 2.3) and waste management authorities are unable to comprehensively regulate illegal dumping of waste, it can be concluded that PAYT is an unsustainable economic instrument of dealing with post-consumer waste generated in developing country households. This conclusion then leaves only one alternative: waste minimisation. As noted by Goddard (1995), when prices for waste collection and disposal are set correctly, significant levels of waste minimisation can be had at a lower cost than all other solid waste management alternatives, hence waste minimisation will become the first priority for households, thus enhancing the economic sustainability of post-consumer waste management systems. This conclusion then leaves social and institutional sustainability to consider.

3.3.4 Social dimension

Social sustainability refers to how receptive and supportive the local community is to waste management options in use and the effective use of the partnership approach in waste management (Chung and Lo, 2003). Within present waste management systems, it seems impossible to develop sustainable waste handling without considerable participation from households (Throne-Holst et al., 2007). Household participation can be either a passive or proactive. Passively, household participation can take the form of community opposition to the siting of waste disposal facilities near residential areas. This social effect is known as NIMBY (Not in my backyard) (Pol et al., 2006). Conversely, household participation can also take place proactively when households make choices as consumers that will affect the amount and type of waste that is generated by the households. Both these aspects are of importance in maintaining socially sustainable post-consumer waste management systems, thus leading to the attainment of zero waste, hence a need for further elaboration on them.

As discussed in Section 1.1, the siting of landfills and incinerators (mostly in developed countries) near residential areas leads to the NIMBY (Not-in-my-backyard) effect. The main factors giving rise to NIMBY are a concern with the negative impact on community aesthetics and property values and the fear of potential health and environmental risks associated with such facilities (Hsu, 2006; Pol et al., 2006). This means that the sitting of these facilities is seen to be inequitable, hence socially unsustainable. Yet these same facilities continue to be major options for dealing with waste arising from households. The implication then is that the amount of post-consumer waste needing disposal needs to be reduced in order to extend the operational lifespan of existing waste disposal facilities.

Reduction of waste necessitates waste minimisation and recycling behaviour by households. As discussed in Sections 2.3 and 2.4, both household waste minimisation and recycling behaviour can be understood by applying the theory of planned behaviour (TPB).

TPB is a psychological framework designed to predict and explain human behaviour in specific contexts (Azjen, 1991) and is based on the assumption that some conscious reasoning is involved in the formation of intentions to perform a behaviour, and that this behaviour is partly under the control of the individual (Knussen et al., 2004). TPB postulates three conceptually independent determinants of intention: "attitude towards behaviour, which refers to the degree to which a person has favourable or unfavourable evaluation of the behaviour in question; social factor termed subjective norm, which refers to the perceived social pressure to perform or not to perform a behaviour and; perceived behavioural control, which refers to the perceived ease or difficulty of performing the behaviour" (Azjen, 1991). These factors were used by Barr et al. (2001) and Tonglet et al. (2004) in explaining waste minimisation and recycling behaviour among households in developed countries. Furthermore, Tonglet et al. (2004) showed that both waste minimisation and recycling can be used to reduce the amount of waste generated by households, thus leading to social sustainability of post-consumer waste management systems. Since both these behaviours have not been comprehensively researched in developing countries, it is postulated that their application to household waste can have the same effect on social sustainability. An understanding of the waste hierarchy, as illustrated in Section 2.2, gives theoretical validity to the conclusion reached.

The importance of the three sustainability criteria in the preceding discussion underscores their importance in attaining sustainable post-consumer waste management systems. However, given that post-consumer waste management is a public sector service, the institutions involved in the provision of that service have an impact on the sustainability of the services provided, hence the need to assess institutional sustainability. Since Municipalities are the primary institutions involved in waste management systems, institutional sustainability involves an assessment of the capability of these institutions to provide waste management services in an "environmentally effective", "economically affordable" and "socially acceptable way" (Morrissey and Browne, 2004).

3.3.5 Institutional dimension

In a sustainability paradigm, the limitations of economic, societal and environmental resources are considered in order to contribute to present and future generation's welfare and can be applied to local, regional and national levels based on political will (Glavic and Lukman, 2007). The exercise of political will is the function of the different stakeholders involved in post-consumer waste management (Joseph, 2006), the primary stakeholders being households and municipalities. Since the sustainability criteria affecting households have already been discussed under the preceding social dimension, it then holds that institutional sustainability is concerned with municipalities. The criteria for assessing institutional sustainability include economic and administrative efficiency; fiscal and distributive equity; accountability; and adaptability (Yandle, 2007). This means that municipalities can be considered institutionally sustainable when they adhere to these criteria, but as Yandle (2007) notes, it is an extremely rare institution that would perform well on most or all the criteria since they are often contradictory. The implication is that for any assessment of institutional sustainability, the criteria most pertinent to the assessment have to be agreed on by the stakeholders involved. However, for the purpose of this thesis, all the criteria will be used to assess institutional sustainability.

In summary, the four main dimensions in sustainability have been discussed and the importance of each dimension in attaining zero waste has been demonstrated. The next section will be a discussion of how the sustainability criteria have been used to modify the waste management system summarised in Figure 3.2 into a zero waste Model suitable for application to post-consumer waste in South Africa.

3.4 Proposed zero waste model

From the overall discussion of the sustainability criteria and existing WM models shown in Figures 3.1 and 3.2, waste minimisation and recycling have been identified as key household behaviours in moving from the current waste management system towards Zero Waste. In Section 2.3, waste minimisation was shown to comprise of two distinct behaviours: reduction at point of purchase and re-use of waste within the house. In Section 2.4, recycling with at-source separation was shown to be the most sustainable way of handling waste that needs disposal after the waste minimisation stage. Moreover, the LCA of the waste fractions being studied showed that both open-loop and close-loop recycling would need to be employed to reprocess the recycled waste. Consequently, paper and plastic would generate residual waste that would need disposal at the end of their life cycles. These results are represented in the proposed zero waste Model shown in Figure 3.4. This is the model that will be used to test the applicability of attaining zero waste to post-consumer waste management in South Africa.

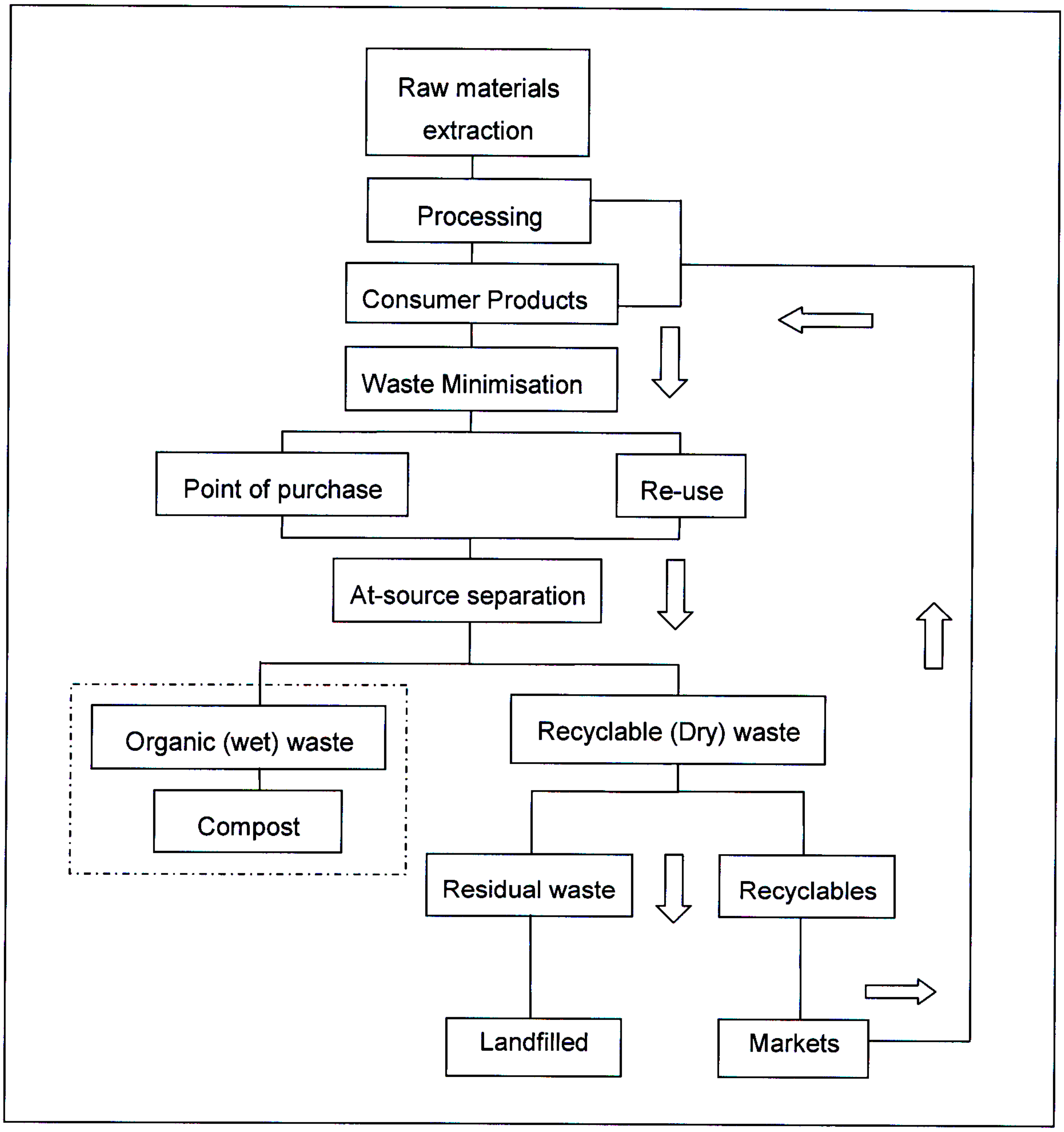

Figure 3.4: The conceptual Zero Waste Model

From Figure 3.4, it can be seen that waste minimisation and recycling have replaced waste generation, thereby reducing the total amount of waste needing disposal. However, collection and transportation of the recyclable and residual fractions are still necessary, though the amount of waste needing disposal has been reduced significantly. Though not shown in the figure, the collected recyclables will need to be sent to a central processing plant, where they will be separated into cans, paper, plastic and glass. Also, the recyclable fractions can either be processed through open-loop or closed-loop recycling depending on the life-cycle state of the materials (Miller, 1996). Finally, the processing of the organic fraction has been highlighted for completeness though it is beyond the scope of this research. Overall, it can be seen that the conceptual model is less complex than that presented in Figure 3.1 and applies the waste hierarchy better than the one presented in Figure 3.2.

Although the proposed conceptual ZWM is suitable for post-consumer waste management in South Africa, cognisance will have to be taken that its application will have to suit the area in which it is being applied. This means that application of the model will have to take into consideration the differences between rural and urban area waste management systems. These differences, along with socio-economic indicators, will be discussed in the next section.

3.5 Context for ZWM application

As already discussed in Section 2.7, waste management systems in South Africa are characterised by similarities with both developed and developing nations. As a result, waste management in formal urban areas with middle to high income groups exhibits features similar to those of developed nations, while those in formal urban areas with low income exhibit features similar to those in developing nations (see Sections 2.6.1 and 2.6.2). With rural areas, the characteristics of waste management systems in these areas are those of developing nations. These differences between urban and rural areas in the country imply that policies and implementation strategies suitable for urban communities may be less applicable to their rural counterparts (Department of Health, 1998). Hence, it is imperative that the zero waste model can be applied with flexibility in both rural and urban areas. It is important at this juncture to define rural and urban areas.

3.5.1 Rural areas

Non-urban or rural areas include commercial farms, small settlements, rural villages and other areas which are further away from towns and cities in the country (Statistics South

Africa, 1998). Furthermore, this definition includes semi-urban areas which are not part of a legally proclaimed urban area, but adjoin it (Stats SA, 1998). The Department of Transport (2005) defines these four types of communities as follows:

- Villages: Population between 500 – 5000, with densities of less than 5 households per hectare. The economic base consists primarily of pensions, public sector services, remittances and some agriculture.
- Dense rural settlements: Population above 5000, higher density, with an economic base dependent on pensions, public sector services and remittances.
- Farming: Population up to 500, with wages and agricultural income forming the economic base.
- Scattered settlements: Population up to 500, with similar economic profile to villages. Some residents live on communal lands.

In South Africa, 42 – 45% of the population resides in rural areas (United Nations Development Programme, 2003; South African Institute of Race Relations, 2004), with almost 80% of this population being located in villages and dense settlements (DoT, 2005). This rural population has the following economic and social characteristics: the poverty rate, which is the proportion of households falling below the poverty line, is 71% (May, 1998); 85% of current roads to rural villages are inadequate (DoT, 2005) and; social indicators show that 45% of rural households do not have access to clean water, 62% do not have access to electricity, 26% do not have access to toilets of any type (DoH, 1998) and the household adult literacy rate is 76% (UNDP, 2001). In summary, rural areas are characterised by poverty, lack of service provision and rudimentary infrastructure.

The lack of service provision was addressed through the enactment of the Local Government Municipal Systems Act (Republic of South Africa, 2000), an Act in which Local Authorities/Municipalities were to strive to ensure that municipal services were provided to the local community in a financially and environmentally sustainable manner. Considering the common economic conditions of rural areas, municipalities cannot cope with providing these essential services (PEACE Foundation, 2004). This lack of service provision results in deterioration of the environment and standards of living, which severely threatens environmental integrity and human health (Matete and Trois, 2006). Thus the duty of service provision in an environmentally effective, economically affordable and socially acceptable manner is negated. These are the conditions within which the ZWM has to be implemented in rural areas, conditions which are the opposite of those existing in urban areas.

3.5.2 Urban areas

An urban area is one which has been legally proclaimed as being urban, for example, towns, cities and metropolitan areas (Stats SA, 1998). These areas have well developed physical infrastructure, advanced banking, financial and manufacturing sectors (de Lange, 2000) and they account for 55 – 58% of the population of South Africa (UNDP, 2003; SAIRR, 2004). This urban areas have the following economic and social characteristics: poverty rate is less than that of rural areas, but unequal in distribution with formal dwellings having a lower rate than informal settlements (May, 1998); average rate of urbanisation, defined as the rate of movement from rural to urban areas, is 65% (SAIRR, 2002) compared with a world average of 55% (UNDP, 2003); informal dwellings in urban areas have risen by 142% (SAIRR, 2002) while formal urban dwellings have increased by only 5% (SAIRR, 2002); only 2% of urban households do not have access to clean water, less than 30% do not have access to electricity, 2% do not have access to toilets of any type (DoH, 1998) and household adult literacy rate is 96% (UNDP, 2001).

3.5.3 Waste management systems

As mentioned in Sections 3.5.1 and 3.5.2 respectively, waste management systems in rural areas are typical of those in developing countries while those in urban areas are typical of developed countries. This means that while waste collection services in urban areas are fully functional, they are typically non-existent in rural areas. This can be seen in Table 3.1, where solid waste collection services are either kerbside or communal for the majority of households (91%) in the urban core, while only 8% of the urban fringe and rural areas and a maximum of 27% of households are served by kerbside and communal skips respectively (DEAT, 2000c). Similarly, waste disposal facilities available in urban areas are either non-existent or rudimentary in rural areas, with more than 73% of rural households disposing of their waste on-site (backyard pit) as shown in Table 3.1. Furthermore, while the majority of households in urban areas can afford to pay for waste services provided, most rural households cannot afford to pay for such services. These environmental and socio-economic differences between rural and urban households underscore the importance of assessing the application of the ZWM separately for the case studies.

It can be seen from the preceding discussion that rural areas and urban areas have different socio-economic indicators. These indicators affect the type of waste management system available in each area: rural areas have no waste system, while urban areas exhibit varying levels of waste management systems. Hence application of the ZWM will have to take these differences into account.

Table 3.1: Collection Service Levels in Settlements in South Africa 1995/96 (DEAT, 2000c)

	Urban Core	Urban Fringe	Dense Rural	Villages	Scattered Settlements	Farms	TOTAL
Households							
Households 1995 (millions)	4.32	0.8	1.06	1.94	0.17	0.61	8.90
Household Distribution 1995	49%	9%	12%	22%	2%	7%	100%
Household growth rate (% pa)	3.5%	1.4%	1.4%	1.2%	0.5%	0%	2.2%
Households 2005 (millions)	6.10	0.92	1.08	2.18	0.18	0.61	11.07
Solid Waste Management							
Kerbside	74%	8%	0%	0%	0%	0%	37%
Communal Skip	17%	16%	27%	0%	0%	5%	13%
None / on site	9%	57%	73%	100%	100%	95%	50%

3.6 Summary

In this chapter, the development of a conceptual zero waste model for application to post-consumer waste in South Africa has been discussed. The development of the ZWM fulfils the first objective of the research documented in this thesis. The ZWM proposed in this chapter is a significant contribution to knowledge with regard to waste management in South Africa and follows on from Chapter 2, where it was shown that such a model does not exist for post-consumer waste management. Furthermore, application of the ZWM will significantly reduce the dependence of current waste systems on landfilling as noted in Chapter 1. Moreover, as shown in Section 3.2, the proposed ZWM applies the different levels of the waste hierarchy to current waste systems according to the order of desirability. This means that waste minimisation is seen as the primary level for reducing increasing waste generation rates, whilst recycling is a secondary measure as opposed to current systems where it is applied as a primary level. Ultimately, application of both these techniques is expected to bring about the sustainability of the waste systems. As discussed in Section 3.3, sustainability is defined in terms of environmental, economic, social and institutional criteria. The use of these criteria has shown that waste minimisation and recycling are the main techniques that can significantly reduce the amount of waste needing disposal. Hence the use of these techniques is encapsulated in the proposed ZWM. However, due to the different waste management systems that are in existence in rural and urban areas, application of the ZWM will be have to be refined to suit the existing waste management systems in these areas. Hence, application of the ZWM will be carried out using a rural area and urban area case study. The results from the two case studies will be discussed in Chapter 5 and 6 respectively, while the methodological approaches used in each case study will be discussed in the next chapter.

CHAPTER 4

4. METHODOLOGICAL APPROACH

4.1 Introduction

The purpose of this chapter is to describe the methodological approach used in the analysis of the application of the zero waste model (ZWM) to post-consumer waste arising from households in typical rural and urban areas in South Africa. This methodological approach is divided into three main sections: a descriptive analysis of the models employed in the sustainability assessment; an assessment of the application of the ZWM to a rural area case study and; an assessment of the application of a ZWM to an urban area case study. The ZWM used in the assessment was developed in the Chapter 3 and is based on attaining environmental, economical, social and institutional sustainability within post-consumer waste management for households. The models employed in the sustainability assessment will be discussed in Section 4.2 while the main differences between rural and urban areas that have led to the use of two case studies will be discussed in Section 4.3, and Sections 4.4 and 4.5 will be a description of the methodology adopted for the rural and urban area case studies respectively. The main points covered in the chapter will be summarised in Section 4.6.

4.2 Sustainability assessment models

As discussed in Section 3.3, sustainable waste management provides an inter-disciplinary framework for addressing the problems of managing MSW in resource constrained developing countries (Joseph, 2006). It comprises of environmental, economic, social and institutional dimensions (Bjorklund and Finnveden, 2005). Given the importance of these sustainability criteria in the present study, it is important to identify and justify the assessment models that will be used for analysing each dimension. Also, the fact that current integrated waste management models do not consider all aspects of sustainability in their application, and none considers the intergenerational effects of the strategies they propose (Morrissey and Browne, 2004), brings about a need to use these separate models in order to comprehensively assess sustainability in post-consumer waste management. Hence the aim of this section is to identify possible assessment models that could be used for each sustainability dimension and to choose, in each case, the most appropriate model that can be used to achieve the objectives of this thesis. This selection process will be carried out by comparing the available models based on their advantages and disadvantages in meeting the objectives of this study. The process will be outlined in the sections that follow, and will begin with choosing a model for assessing environmental sustainability.

4.2.1 Environmental model

The primary goal for environmental sustainability for post-consumer waste is to reduce the amount of waste needing disposal. This reduction in waste disposed will in turn reduce air and ground water emissions arising from the disposed waste, and hence reduce the adverse environmental impacts of these emissions (DEAT, 2000b). As shown by den Boer et al. (2007), the general objectives for environmental sustainability can be summarised as rational resource consumption and reduction of environmental pollution. It then follows that the model employed in attaining environmental sustainability in the application of the ZWM should focus attention on reducing the amount of waste needing disposal.

Given that the focus of this thesis is on achieving zero waste in post-consumer waste, the most appropriate model for environmental sustainability is a combination of waste minimisation and recycling with at-source separation. In order to demonstrate the impact of these strategies on post-consumer waste, the amount of waste generated by households has to be quantified and characterised. This requires measuring the amount of waste generated by households and then conducting a waste stream analysis in order to identify the relative proportions of different materials in the generated waste. The removal of the recyclable fractions then gives an indication of how much residual waste will need disposal, and consequently, the reduction in emissions due to the waste that was not disposed. The landfill volume space that is saved as a result of only the residual waste being disposed of is termed landfill space saving (LSS) in this thesis.

Although LSS has been chosen to be the most appropriate model for assessing environmental sustainability, it could be argued that a LCA type model could be employed in carrying out the environmental assessment instead. This would be the case if a LCA type model did not have serious limitations when it comes to application in post-consumer waste assessment (Stotko, 2006). The first limitation is that LCA type models focus on the entire life cycle of a product, thus making it difficult to establish where the system boundary for the assessment is when only post-consumer waste is being analysed (Morrissey and Browne, 2004). Secondly, LCA techniques are unable to assess the actual environmental effects of the system that is being studied (Morrissey and Browne, 2004). Furthermore, these environmental impacts are strongly determined by place, time and method in which a particular waste option is operated, factors which are not incorporated in LCA type model (Stotko, 2006). Thirdly, given the complex data sets required for LCA analysis and the variations available in LCA modelling, the results produced for a single product may differ in practice (Morrissey and Browne, 2004). This preceding discussion shows that LCA type models are best suited for general rather than specific assessment of environmental impacts of waste management options. Hence given that the research carried out in this thesis is concerned with a specific environmental impacts assessment, LCA type models are not suitable for analysing environmental sustainability in this case. This then leaves the LSS model being the most appropriate for assessing environmental sustainability in this research.

4.2.2 Economic model

According to den Boer et al. (2007), economic sustainability "implies the least expensive waste management system provided that it secures sufficient revenue to ensure an economically sound and continuous operation and coverage of all system aftercare expenses for a period stipulated by law". This means that economic sustainability is concerned about the overall financial costs of the system as compared with the overall financial revenues over a given period of time. For post-consumer waste, the central issue in economic sustainability is the distinction between costs incurred by the municipalities in delivering the waste management service and the revenue generated from municipal rates and tipping fees (den Boer et al., 2007). This economic assessment can be analysed using cost benefit analysis (CBA) or multi-criteria decision analysis (MCDA) models.

CBA is a tool used in decision making in order to assess the expected economic costs and benefits of a set of scenarios by translating all impacts into a common unit of measurement: monetary (DEAT, 2004; Morrissey and Browne, 2004). According to Stotko (2006), CBA generally involves the optimisation of a particular waste management system by determining the combination of options that result in the lowest operating costs. The use of CBA is beneficial in that the results are presented in a clear manner with all impacts enumerated into a single monetary value, which enables decision makers to compare the use of financial resources between the different scenarios (DEAT, 2004). One of the major limitations of CBA is that there is uncertainty in the estimation of the cost of environmental and social impacts (Morrissey and Browne, 2004). However, for the purpose of this research, this limitation is negated by the fact that all environmental and social impacts are assessed using separate models. This then leaves one other limitation: the assumption that prices may change during the planning horizon of the waste management programme, thus negatively influencing the result of the economical assessment (DEAT, 2004; Morrissey and Browne, 2004).

In contrast to CBA, MCDA is a decision tool used to evaluate the effectiveness of different waste management schemes in a multidimensional way that allows for several variable criteria to be included in the model (Stotko, 2006). The use of MCDA is beneficial in that it "allows for a systematic approach for evaluating policy; quantitative and qualitative information can be incorporated into the model allowing for evaluation beyond purely economic consequences and; the multi-criteria technique that it uses offers a level of flexibility and inclusiveness that purely economic models tend to lack" (Morrissey and Browne, 2004). Conversely, MCDA also has limitations: the resultant scheme ranking analysis produces a set of favourable schemes rather than an optimum combination of schemes that produce the best solution (Stotko, 2006) and; the allocation of weights for each criteria in the assessment is subjective and changing the weights can lead to a different set of results (Morrissey and Browne, 2004).

In comparing CBA and MCDA for use in assessing economic sustainability, it can be seen that CBA is the best option. The reasons for this conclusion is that firstly, CBA is purely an economic model that yields one final result that can easily be interpreted, which is different to MCDA that yields multiple solutions. Secondly, CBA yields itself to an objective analysis once the relevant economic impacts are considered, whereas MCDA yields multiple solutions that are evaluated subjectively, which means that the results can change if the weightings are changed. Thirdly, CBA combines different scheme options into one cost effective scheme while MCDA can only rank the options and is unable to combine these options into one cost effective solution. Finally, CBA can be employed for any type of economic analysis once the economic variables are known, an advantage that is negated by the use of predetermined weights in MCDA.

4.2.3 Social model

In broad terms, social sustainability in waste management is the ethical behaviour of the waste management system towards society (den Boer et al., 2007). Furthermore, social sustainability means that the waste system being implemented has to be acceptable and equitable to society, and be able to perform the function for which it is intended (den Boer et al., 2007). Indeed community response to waste management initiatives, in terms of planning and operation, is an important factor that can foster or hinder the development of such initiatives (Wilson et al., 2001). Stated in another way, the actions of householders are paramount to the success of sustainable waste management policies (Wilson and Williams, 2007). These assertions are summarised by Joos et al. (1999), who state that the problems of public participation in planning and implementation of waste management programmes are no less important than technical or economic aspects that need to be considered in decision making. This means that social assessment of waste management programmes is an important aspect of assessing overall sustainability. The most common tool used in conducting a social assessment is a questionnaire (Warwick and Lininger, 1975; Fink, 2003).

Since a questionnaire is the most common tool for assessing social sustainability in waste management, it was applied in this research. The use of a questionnaire is beneficial in that various types of households can be reached by using a questionnaire; a questionnaire can be used to gather data using a small sample size in order to predict the behaviour of an entire population; a questionnaire can be adapted to the time constraints of households being studied and the type of study being undertaken and; the use of software in analysis reduces the amount of time needed to analyse the questionnaire. Another important consideration in using a questionnaire is that different communities can be analysed using the same questionnaire and the results can be easily compared. Hence the questionnaire is the most appropriate tool for assessing social sustainability in order to meet the objectives of this research.

4.2.4 Institutional model

While social assessment focuses on the willingness of households to support and participate in waste management systems, thus bringing about the systems' sustainability, institutional assessment focuses on the capacity of waste management service providers to implement these waste management systems. As discussed in Section 3.3, this service provision has to be carried out in an environmentally effective, economically affordable and socially acceptable manner. Thus institutional assessment focuses on the administrative capabilities and financial resources that are available to the service provider enabling it to fulfil its function. In South Africa, Municipalities are the main waste management service with regards to post-consumer waste. Hence, an institutional assessment focuses on the ability of municipalities to provide waste management services to households in a sustainable manner. This institutional assessment can be carried out using the Institutional Analysis and Development (IAD) Framework (Ostrom et al., 1994; Gibson, 2004; Koontz, 2006; Clement and Amezaga, 2009 and Dong et al., 2009). It is the adaptability of the IAD framework, as will be shown below, that makes it an ideal model for assessing institutional sustainability of zero waste schemes developed using the ZWM.

The IAD framework is a multidisciplinary tool that is used to frame policy research on public goods and quasi-public goods (Rudd, 2004) and the provision of public services (Gibson, 2005). IAD has "roots in classical political economy; neoclassical microeconomic theory, institutional economics; public choice theory, transactional cost economics and; non-cooperative game theory" (Ostrom et al., 1994). At a general level, IAD has been used in institutional analysis of a number of independent issues (Gibson, 2005). For example, IAD has been used in the study of a metropolitan organization, in the theory of public goods, in the sustenance of rural infrastructure in developing countries, and extensively in the work on common pool resources (CPR) (Ostrom, 1990; Ostrom et al., 1994). As shown by Rudd (2004), IAD can be applied at multiple levels, thus linking the constitutional level of an organization to its operational level (Gibson, 2005). More specifically, the IAD framework has been used in the analysis of an institution's structure and performance (Dong et al., 2009). As shown by Dong et al. (2009), the IAD framework does not rely on a single measure of institutional effectiveness. Since the institutions that will be assessed in this thesis are located in rural and urban areas, and given that waste management is a public service with multiple levels of operation, the IAD framework in considered the best tool for conducting institutional analysis.

In terms of waste management, IAD framework can be used to assess how well municipalities are functioning in their provision of waste management services (Yandle, 2007). The framework encourages sustainability analysis that takes full account of institutional variables that influence and shape the behaviour of any given institution (Rudd, 2004). Also, the IAD provides a solid foundation for addressing questions about inter-organizational relationships relating to the environment and decision making (Koontz, 2006). According to Yandle (2007), the IAD framework identifies four criteria for assessing institutional performance: "efficiency, which is measured in terms of economic and administrative efficiency; equity, which is divided into fiscal and redistributive equity; accountability, which is a principle that institutions should be held responsible for their actions and; adaptability, which is the ability of an institution to respond to change over time". Yandle (2007) further defines economic efficiency as the benefits gained relative to expenditure, while administrative efficiency examines the costs of maintaining institutional arrangements.

While the discussion in this section has focused on the sub-models that will be used in assessing sustainability of zero waste schemes developed from the zero waste model, the next section, Section 4.3, will be a discussion on the methodology used to assess the possibility of zero waste in a rural area case study. The methodology used in the urban area case study will be discussed in Section 4.4.

4.3 Methodological approach to the rural case study

The aim of this section is to describe how a sustainability assessment was carried out on an existing waste management system in the rural area of Ndumo. This assessment was followed by application of the ZWM described in Section 3.4 and the results obtained were used to propose a zero waste scheme (ZWS) for implementation in Ndumo. It was also the aim of the research to test the proposed ZWS in Ndumo, but this practical application could not be undertaken due to a lack of financial and administrative support from the Municipality responsible for Ndumo. For the purpose of this study, Ndumo was identified as a representative case study due to the availability of an existing waste management project that was part of a 'poverty alleviation' development promoted by the PEACE Foundation (a non-governmental organisation). The methodology adopted in the case study will be further described.

Data collection was carried out in a series of field trips conducted between March and October 2004. The objectives of the data collection were as follows: to establish background information with regards to the waste component of the PEACE Foundation development in Ndumo; to assess the sustainability of the waste management component based on the sustainability criteria identified in Section 3.3; to carry out a life cycle assessment (LCA) of the recyclables collected in the project; to develop a ZWS based on the ZWM established in Section 3.4; and hence empirically test the applicability of the ZWS in Ndumo.

4.3.1 Background information on the waste project

Census data for Ndumo was sourced from the Statistics South Africa website (www.statssa.gov.za) in order to show that the rural area characteristics identified in Section 3.5.1 were valid for Ndumo. PEACE foundation staff involved in the waste project were interviewed in order to establish background information for the set up of the project. This included the executive director, the projects co-ordinator and the facilitator for the KwaZulu-Natal region. The Environmental consultant for the Project was also interviewed. The interview was conducted by means of electronic mail. The PEACE website (www.peacefoundation.org.za) and the DEAT website (www.environment.gov.za) were also used as sources of information. During the site visits, informal interviews were conducted with members of the Ndumo community involved in the project to complement the information gathered formally. Attendance at PEACE board meetings and Ndumo Trust meetings provided another avenue for background information on the project. Secondary information was sourced from reports on research done in the Ndumo by Thoeresz (2004).

4.3.2 PEACE waste project

The assessment of the waste project was carried out in four phases. The first phase involved extensive interviews with the Project co-ordinator for PEACE, the PEACE Centre manager, and the waste project supervisor. The second phase involved the assessment of the already established waste facilities located at the PEACE Centre. These facilities include a waste shed, waste storage bags, waste collection trolleys, a waste disposal pit and a waste incinerator. The purpose of each of the aforementioned facilities was clarified in the form of a questionnaire to be filled in by the project consultant. The third phase involved quantifying the recyclables collected during the course of the project and then estimating the income that could be generated from the sale of the recyclables. The last phase involved a general assessment of the skills of the workers involved in the waste project. This assessment was done by analysing the training programme that the workers underwent.

4.3.3 Sustainability assessment of waste project

The sustainability of the waste project was carried out using the criteria identified in Section 3.3. The purpose of sustainability assessment was to establish the functionality of the existing waste project, thus identifying whether there was a need for the ZWM to be applied in Ndumo. Environmental sustainability was assessed by identifying the waste disposal infrastructure provided for stakeholders in the Ndumo waste project. Economical sustainability was assessed by identifying the financial incentives provided for the workers in the waste project and the cost of transporting the recyclables collected in project. These costs were compared with the benefits that could be derived from the sale of recyclables collected in the project and service charges to stakeholders since the Municipality responsible for Ndumo could not finance the project. This assessment represents a simple cost benefit analysis (CBA). Social sustainability was carried out by assessing whether the waste collection services were provided to the stakeholders in an equitable manner as required by the Local Government Municipal Systems Act (Act 117 of 1998). Finally institutional sustainability was assessed by assessing the financial and administrative capacity of the institutional authority responsible for waste project.

4.3.4 End-life cycle assessment

An end-life cycle assessment (ELCA) was conducted for the recyclable fractions arising from the waste project. This was done in order to determine the final destination of the recyclables, as well as the possible products that could be produced from the recyclables for use in Ndumo. Possible markets for these products were also sourced. The transportation of the recyclables from Ndumo to the Jozini Recycling Centre, which is the nearest buy-back centre to Ndumo, was also investigated. The final destination of the recyclables collected at the Jozini Recycling Centre was also investigated.

4.3.5 Proposed zero waste scheme

The results of the assessment in Section 4.3.1 – 4.3.4 were used in conjunction with the ZWM to develop a zero waste scheme for Ndumo. The proposal was tabled to the PEACE Foundation to carry out a pilot ZWS in Ndumo. The possibility of the Jozini Municipality taking over the project at the completion of the pilot project was also discussed. The proposed ZWS was also subjected to a sustainability assessment as was the case for the waste project.

4.3.5.1 Environmental analysis

A qualitative and quantitative analysis of the environmental impact of the proposed ZWS was carried out. The qualitative analysis involved the identification of benefits arising from the introduction of waste collection and recycling services for household waste. This part of the analysis was done to show that the ZWS met the sustainability criteria by having positive environmental impact on waste management in Ndumo. The quantitative analysis was concerned with the estimation of the amount of recyclables that could be generated by households in Ndumo; waste that would not need to be disposed of in an environmentally suitable manner given the lack of waste disposal facilities in Ndumo. Given that no waste stream data was available for Ndumo and there is very little or no published data for waste generation and recycling rates in rural areas, different scenarios of waste generation and recycling rates were used to calculate the potential yield of recyclables in Ndumo. The results of this analysis were used to show that a ZWS could be implemented in Ndumo. Also, the results were used in assessing the economic sustainability of the proposed ZWS.

4.3.5.2 Economical analysis

A simplified cost benefit analysis (CBA) of the ZWS was carried out in order to assess whether application of the ZWS would be economically beneficial to Ndumo. The CBA focused on both the costs and benefits that would arise as a result of the implementation of the proposed ZWS. The costs assessed include the wages of the workers to collect the waste and to separate and sort the recyclables; the transportation costs incurred in transporting the recyclables to the nearest buy-back centre; and the disposal costs for the residual fractions. The costs that would be incurred by the implementing authority were not included in the analysis because it was expected that they would be borne by authority or subsidized by government given the financial conditions that exist in rural areas; conditions which were briefly discussed in Section 4.3. Costs for setting up an MRF were not included in the CBA because it was expected that the volume of recyclables arising from the ZWS would not exceed the capacity of the existing MRF. Conversely, the economic benefits arising from the implementation of the ZWS involve the sale of recyclables at the Buy-back centre nearest to Ndumo. The recyclables prices were sourced from a research done by Green et al. (2004) at the Jozini Recycling Centre, which is the closest buy-back centre to Ndumo. While the economic analysis focused on the financial aspects of the implementation of the ZWS, the social analysis focused on the social impacts of the proposed ZWS.

4.3.5.3 Social analysis

The social assessment of the proposed ZWS involved the qualitative assessment of the possible impacts that could arise as a result of the application of the ZWS. These impacts were identified from reports on research that had been done in Ndumo by Thoeresz (2004). It had been the plan to assess the social impacts of the ZWS through a questionnaire, but the questionnaire was deemed inappropriate given the expectations that it would raise in an area that lacks many infrastructure services, hence the decision to use the SIT reports. These reports were consulted in order to check if some of the social needs present in Ndumo could be alleviated by the implementation of the ZWS.

4.3.5.4 Institutional analysis

While the social assessment focused attention on the ability of the stakeholders to implement and maintain the proposed ZWS, institutional assessment focused on the supply-side aspects of the implementation and maintenance of the ZWS. These supply-side aspects focused on the ability of the Jozini Municipality to effectively manage the ZWS in terms of administration and financial support. This part of the assessment involved interviews with a Municipal Officer from Jozini as well as consultation of SIT reports documenting the institutional arrangements existing in Ndumo.

This preceding discussion of the theoretical sustainability assessment brings to conclusion the methodological approach for the rural area case study. The next section will focus on the methodological approach adopted to investigate the applicability of the ZWM to an urban area case study.

4.4 Methodological approach to the urban case study

The aim of this section is to describe the development of a zero waste scheme (ZWS) by applying the ZWM developed in Chapter 3 into an established integrated waste management system within the Durban area. Two communities surrounding the Mariannhill Landfill site were used as a case study: Mariannhill Park and Nazareth. The Mariannhill Park community represents a relatively middle income area and Nazareth represents a relatively low income area. The waste generated in these two areas is disposed of at Mariannhill landfill; hence the impact of the intended ZWS, applied in these two areas, on landfill volumes at Mariannhill Landfill could be readily assessed. Furthermore, the waste collection systems used in the two areas are different; hence the impact of this difference on possible waste minimisation behaviour and recycling attitudes of households could also be assessed.

It was also the aim of the research to test the proposed ZWS in the two aforementioned areas in Durban, but this empirical application could not be undertaken due to a lack of financial and administrative support from the Municipality responsible for these areas. For the purpose of this study, Durban was identified as a representative case study due to the existence of an integrated waste management system which is co-ordinated by Durban Solid Waste (DSW) on behalf of the eThekwini Municipality. The methodology adopted in the case study will be further described.

Data collection was conducted between January 2005 and December 2006, with additional data collected as appropriate in the period thereafter. The objectives of the data collection were as follows: to carry out an analysis of the current waste management systems within the case study areas; to determine the amount of recyclables in the post-consumer waste arising from the case study areas in order to identify their type, nature and quantity; to carry out a end-life cycle assessment of the recyclable fractions in order to identify suitable recyclers/converters/buyers; to develop a ZWS based on the ZWM established in Section 3.4; to empirically test the applicability of the ZWS in the two case study areas; and hence assess the sustainability of the ZWS based on the sustainability criteria identified in Section 3.3. A detailed discussion of the methodology adopted to achieve these objectives follows.

4.4.1 Proposed zero waste scheme

A theoretical ZWS, based on the ZWM developed in Chapter 3, was proposed for application in Mariannhill Park and Nazareth. The ZWS was then assessed using the four sustainability criteria: environmental, economical, social and institutional. The methodology adopted in carrying out the assessment based on each criteria is further discussed.

4.4.2 Environmental assessment

As explained in Section 4.2.1, the amount of waste generated by households has to be quantified and characterised, and ultimately, the landfill volume space that could be saved as a result of only the residual waste being disposed of has to be calculated. Thus the purpose of the environmental assessment was to identify the waste collection systems operational in the two case study areas, identify the amount of household solid waste generated by them, calculate the potential yield of recyclables from these waste streams, calculate the potential space savings due to the non-disposal of the recyclable fractions and finally, to determine the ultimate destination of the recyclable fractions.

4.4.2.1 Waste management system

Information on the current waste management systems was sourced from Durban Solid Waste (DSW) who are responsible for collecting waste within the eThekwini Municipality and sourced from the Solid waste management - Status quo 2002 and Master plan 2002 reports prepared for DSW by SKC Engineers. Interviews were also conducted with the authorities within DSW. Online maps, along with data pertaining to the number of households and relevant household statistics and the waste collection methods used in the two areas were sourced from the municipality website (http://capmon.durban.gov.za), as well as DSW staff responsible for waste management systems within the two case study areas.

4.4.2.2 Waste arising

An analysis of the domestic waste generated in both case study areas was conducted. For each area data for five years (2000 – 2004) was collected and analysed. The data was sourced from DSW manager responsible for Mariannhill Park and Nazareth. This data was statistically analysed, using the F-statistic, to check whether the variation between the years and between seasons was significant as this could have an impact on the operation of the proposed ZWS. However, only 2003 and 2004 were used in subsequent analysis given that price assumptions for this short time-span could be assumed to be stable, especially for the Economic Assessment. Along with the number of households and their average occupancy, this data was used to calculate the per capita waste generation rates for the two areas.

For Mariannhill Park, direct records for waste generation were not available. But Mariannhill Park forms part of Pinetown South, for which waste generation data was available. A conversion factor was then applied to this data to estimate waste generation amounts for Mariannhill Park. This conversion factor was based on the number of housing units in Mariannhill Park divided by the number of housing units in Pinetown South. The number of housing units for Pinetown South was sourced from the Status Quo Report (SKC, 2002a).

4.4.2.3 Recyclable quantities

The percentage of the recyclable components of the waste stream could not be determined directly for each area. Instead, data from previous studies in the eThekwini Municipality was used. This data was from areas with waste generation data and population characteristics comparable with the case study areas. The areas were chosen based on geographic proximity to the case study areas, as well as compatibility in income levels and history of service provision. Waste composition data for Durban North was used for the waste stream analysis for Mariannhill Park. Waste composition data for Umlazi was used for Nazareth. The stream data was assumed to remain constant for both years of analysis. This was considered a reasonable assumption given that there was no significant difference in waste generation between the two years, and the fact that the analysis period was short. The computational formulas for the recyclables yield are given in Equations 4.1 and 4.2.

Total mass of Recyclables = Total waste generated x Fraction of recyclables

$R_T = W_T \times f_T$ ______ Equation 4.1

where: $f_T = f_{hp} + f_{sp} + f_g + f_c + f_{card} + f_p$ ______ Equation 4.2

and f_{hp} – fraction for hard plastics

f_{sp} – fraction for soft plastics

f_g – fraction for glass

f_c – fraction for cans

f_{card} – fraction for cardboard

f_p – fraction for paper

Four scenarios were investigated using the recyclable yield and they were applied to each case study area: At-source separation (S1-a) and (S1-b), Voluntary (S2) and Mixed-waste (S3). Scenario 1 represents a recycling scheme with at-source separation, which was further divided into the ideal (a) and practical (b). Both are representative of the Hummel model as shown in Figure 4.1. The computational formulas are given in Equation 4.3.

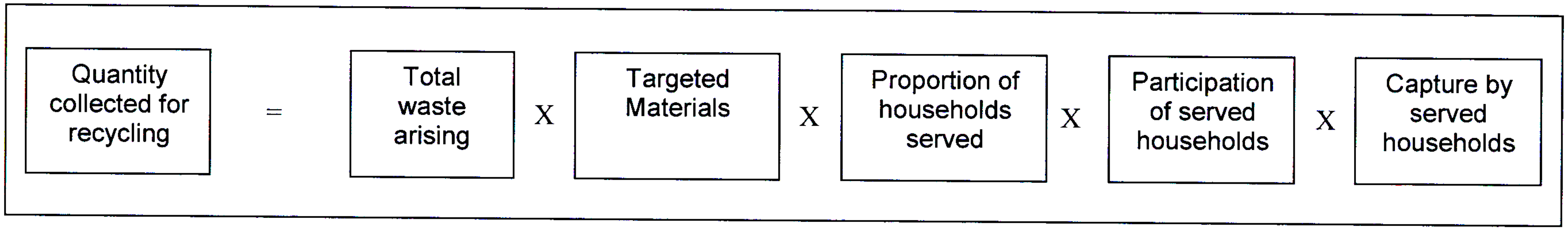

Figure 4.1 Hummel Model (Hummel, 2000)

Total Recyclables = Total Waste x Targeted materials x Proportion of households served x Participation of households served x Capture by served households

$R_T = W_T \times f_T \times S_H \times P_H \times C_H$ ____________________ Equation 4.3

where:
W_T – total waste
f_T – total fraction of recyclables (as in Equation 4.2)
S_H – proportion of households served
P_H – participation of households served
C_H – capture by served households

For Scenario 1 a)
S_H - assumed to be 100%
P_H - assumed to be 100%
C_H - assumed to be 100%

For Scenario 1 b)
S_H - assumed to be 100%
P_H - as measured in Social Assessment
C_H - as measured in Social Assessment

Scenario 2 represents voluntary recycling, where 30% of the total solid waste generated in each area is recyclable. This figure is the average recycling rate in South Africa over a 9 year period (1991 – 2000) as shown in Section 2.6.2, Table 2.1. It is also in agreement with Hugo (2004) who states that average waste recovery in South Africa seems to be in the vicinity of 30%. While 30% is applied to the total waste generated, the proportion of recyclables remains as represented in Equation 4.2 and is different for the two case study areas. The computational formulas are given in Equations 4.4 and 4.5.

$R_T = W_T \times f_V$ ______________________________ Equation 4.4

where: $f_V = 0.3f_T$ ________________________ Equation 4.5

Scenario 3, which represents mixed-waste recycling, takes into account current recyclable fractions separated from the waste entering the Mariannhill landfill site from the various waste generation points. Furthermore, the recyclables are of commercial value rather than total fractions available in the waste. Although the recyclable types are the same, the fractions are different from the ones in Equation 4.2. Also, these fractions are used for both case study areas unlike in Scenarios 1 and 2. The computational formulas are given in Equations 4.6 and 4.7.

$$R_T = W_T \times f_M \qquad \text{Equation 4.6}$$

where: $$f_M = f_{Mhp} + f_{Msp} + f_{Mg} + f_{Mc} + f_{Mcard} + f_{Mp} \qquad \text{Equation 4.7}$$

and

f_{Mhp} – fraction for hard plastics

f_{Msp} – fraction for soft plastics

f_{Mg} – fraction for glass

f_{Mc} – fraction for cans

f_{Mcard} – fraction for cardboard

f_{Mp} – fraction for paper

The Scenarios described in this section are summarised in Table 4.1.

4.4.2.4 End-life cycle assessment

An end-life cycle assessment (ELCA) was carried out for the recyclable fractions, which include paper (high grade white paper and cardboard), plastic (PET, HDPE and LDPE), glass and cans. The Westmead Community Recycling Centre was used as a case study in identifying suitable recyclers/buyers/converters for the recyclables. All the materials recycled by the centre were identified as well as the buyers and prices for each material. This information was collected by interviewing the owner/manager of the centre. For each recyclable fraction of interest, the main recycler was identified. These recyclers were then interviewed to provide information on the recycling process for each fraction as well as the end products of the recycling process. Hard copies and online copies of News letters produced by the recyclers were also used in the gathering of information.

Table 4.1: Summary of recyclables yield scenarios for urban area

Scenario		Characteristic properties
1a)	**At-source separation (Ideal case)**	Maximum proportion of recyclables as determined in the Waste Stream Analysis
		Relative fractions of recyclables as determined in the Waste Stream Analysis
		Proportion of households served = 100%
		Participation rate of households served = 100%
		Capture rate of recyclables by households = 100%
1b)	**At-source separation (Realistic case)**	Maximum fraction of recyclables as determined in the Waste Stream Analysis
		Relative fractions of recyclables as determined in the Waste Stream Analysis
		Proportion of households served = 100%
		Participation rate of households served = as measured in Social Analysis
		Capture rate of recyclables by households = as measured in Social Analysis
2	**Voluntary Recycling**	Proportion of recyclables = 30% of total waste generated
		Relative fractions of recyclables as determined in the Waste Stream Analysis
		Minimal household participation in recycling as is the case currently
3	**Mixed Waste Recycling**	Capture of recyclables based on the commercial value at present
		Relative composition of recyclables as determined in a pilot MRF facility at Mariannhill Landfill Site
		No household participation

4.4.2.5 Landfill Space Saving

Landfill space saving is the volume of landfill not utilised as a result of the non-disposal of the recyclables at the landfill. Given that the density of the compacted recyclables is lower than that of mixed waste, it was decided to use the density of mixed waste as it gave a conservative value for LSS. The computational formula for this section of the analysis is given in Equations 4.8.

Total Volume Saved = Total mass of Recyclables / Density of disposed mixed waste

$$VS_T = R_T / D_W \qquad \text{Equation 4.8}$$

where: VS_T – Total saved volume

D_W – Density of disposed waste (1200kg/m^3 – SKC, 2002a).

4.4.3 Social assessment

As already explained in Section 4.2.3, community response to waste management initiatives, in terms of planning and operation, is an important factor that can foster or hinder the development of such initiatives (Wilson et al., 2001). This means that without the cooperation of households, the proposed ZWS would not be operational in the case study areas. Hence a self-administered questionnaire was applied in both areas to the test the willingness of households to participate in the proposed ZWS. The Questionnaire, both the English and isiZulu version, is attached in Appendix B.3.

4.4.3.1 Questionnaire design

Since this was an exploratory study, it was decided to use a self-administered questionnaire because it could be applied with relative ease compared to other types of questionnaires. Secondly, the questionnaire could be filled in independently by a respondent in the presence of the interview facilitator and any questions raised by the respondent could be explained during the interview process. This type of interview process meant that a high response rate could be achieved as compared with a posted self-administered questionnaire which usually achieves a 40% – 50% response rate (Warwick and Lininger, 1975) and is more costly to apply. The advantages of using a self administered questionnaire are summarised by Oppenhiem (2003): method ensures high response rates; accurate sampling; minimum interviewer bias while permitting necessary explanation of questions; and giving the benefit of a degree of personal contact. The point raised on accurate sampling will be discussed further in Section 4.5.3.2. The other main advantages of using a self-administered questionnaire are that it has low data collection and data processing costs (Oppenhiem, 2003).

Another advantage of using a self administered questionnaire was that a similar questionnaire had already been applied by Popat (2003) in Durban North on a study in waste minimisation and recycling attitudes. For the purpose of this study, questions on willingness to recycle and willingness to source separate were then added to the questionnaire while keeping the rest of the questionnaire intact. As such, it was not necessary to do a pilot study of the questionnaire as its application had been successful in another area within the eThekwini Municipality.

4.4.3.2 Questionnaire application

The questionnaire was applied in the case study areas using cluster sampling. Cluster sampling is defined as "a sampling procedure of selection in which the elements for the sample are chosen from the population in groups or clusters rather than singly" (Warwick and Lininger, 1975). This choice of sampling means that the sample data would be probabilistic hence the statistical inferences pertaining to the population within the sampled areas could be made from the sample parameters. The clusters chosen for the samples involved houses and flats in Mariannhill Park and entire road sections within Nazareth where the types of housing were observed to be uniform. In each cluster, all households were interviewed, with the main requirement that the person filling in the questionnaire had to be 18 years and above. Only one person in each household was interviewed and the views expressed were taken as that of the household. Thus the sampling unit for the survey was a household.

Analysis of the questionnaires from Mariannhill Park and Nazareth showed that the expected income levels between the two areas were not significant as expected, so a third area of relatively high income, as determined from the available statistics from the Municipality website, was chosen for application of the questionnaire. The area chosen was Westville Central. Due to time constraints, it was not possible to do clustered sampling in Westville Central, so convenience sampling was used instead. This means that the results from the sample for that area could be generalised for the population within the area, without an accurate measure of the error in the estimate.

The overall sample size for the survey was determined using Equation 4.9:

$$n = \frac{z^2 p(1-p)}{e^2} \qquad \text{Equation 4.9}$$

where: n = sample size

p = value used to represent the population proportion

e= Desired margin of error

z = critical value from the standard normal table

With no information available on the p – value, p = 0.5 was used as this represented the maximum value that could be attained in Equation 4.9 given that z-value and e-value are chosen parameters for the level of accuracy required in the study. The level of confidence that was chosen for this study was the conventional 95%, which then yielded the corresponding z-value. A conservative margin of error was set at 6.53%.

The sample size for each community was determined according to Equation 4.10:

$$\text{Community sample size} = \left[\frac{Number.of..households}{\sum Number..of..households}\right] \times n \qquad \text{Equation 4.10}$$

The number of households was determined from the available statistics for the three areas on the Municipality website (http://capmon.durban.gov.za). The total number of households was a summation of the number of households in the three areas.

As already mentioned, field application of the questionnaire was based on cluster sampling for Mariannhill Park and Nazareth, while convenience sampling was used in Westville Central. Given the demographics obtained from the website, questionnaires for Mariannhill Park and Nazareth were printed in English and isiZulu, while those for Westville Central were printed in English.

4.4.3.3 Questionnaire analysis

The completed questionnaires were analysed using SPSS (Statistical Package for the Social Sciences). Firstly descriptives of the demographic variables were conducted. Secondly, a reliability analysis was conducted on the scales for waste minimisation behaviour and attitudes towards recycling. Thirdly, inference testing was carried out based on the demographic (independent) variables and their ability to predict the dependent variables such as willingness to recycle, willingness to source-separate recyclables and preferred method of collection for the separated recyclables. Also, when waste minimisation and recycling attitudes scales were reliable, the relationship between these and the independent variables were also established. Finally, interpretation of the results was carried out based on their possible impact on the proposed ZWS. This interpretation included the use of the results for willingness to source-separate and the percentages for recycling the various recyclables in modifying the results of the environmental assessment for use in the CBA.

In terms of inference testing, the following hypotheses were tested:

- (H1) Willingness to recycle can be predicted using each of the independent variables
- (H2) Willingness to source-separate recyclable waste can be predicted using each of the independent variables
- (H3) The level of income is based on the geographic location of the respondent, which means that the average income levels for the three areas are expected to be different.
- (H4) Their response to the willingness to recycle and source-separate the recycled waste, and type of collection system for the recyclables

H1 and H2 were tested separately for Mariannhill Park and Nazareth, while H3 and H4 were tested using the three areas: Mariannhill Park, Nazareth and Westville Central.

For both H1 and H2, predicting the outcome based on gender was tested using the independent t-test given that the data scale was nominal and consisted of only two categories. Predictions based on age, home language and type of dwelling were made using the Kruskal-Wallis test given that the data scale for these variables was nominal, whilst predictions based on number of occupants in a household and household income level were made using the correlation (Spearman's rho) test since the variables were on an ordinal data scale. All the tests using the independent variables to predict the dependent variables were non-parametric due to the fact that non-parametric tests do not assume that the data is normally distributed (Brace et al., 2003).

For H3, two inferential tests were used to test the difference in average income level between the three areas. These were the correlation test, using the non-parametric Spearman's rho and cross-tabulations. The descriptive data for income in each of the three areas were used as a check on the results of the inferential tests.

For H4, cross-tabs were carried out to see whether the responses, from the three communities, to willingness to recycle, willingness to source-separate and collection method for recyclables were associated or not.

Due to the nature of data collection for the three areas, the inferential tests could be generalised to communities with similar population characteristics to Mariannhill Park and Nazareth for H1 and H2 only, while the results for H3 and H4 are specific only to the three areas surveyed.

4.4.4 Economical assessment

A cost benefit analysis (CBA) was carried out to assess the economical benefits of the proposed ZWS as compared to conventional collection and disposal of solid waste. The CBA focuses on cost savings arising from the non-disposal of waste at the landfill. More importantly, the CBA also considers the income that could be generated from the sale of the recyclables to suitable buyers. Due to the volatility in the commodity prices for recyclables, a high profit and a low profit scenario were investigated in order to determine the possible income range arising from the sale of recyclables. Each scenario in Section 4.4.2.3 considered the two case study areas collectively and was carried out separately for each year, thus yielding 16 sets of calculations for the two years of analysis.

The framework for the analysis was the same for scenario 1a) and scenario 1 b), and different for scenarios 2 and 3. These two frameworks will be outlined separately.

For scenario 1 a) and 1 b), the framework is as follows:

- All costs arising from the disposal of household solid waste were calculated. These are:
    - Collection costs

      These are transportation costs incurred in the collection of waste from households and transportation by the service provider to the landfill. This is inclusive of vehicle maintenance and labour costs.
    - Disposal costs
        - Capital

          These are construction costs incurred in preparing the landfill to receive waste and have been averaged out for each cubic metre of landfill space created
        - Operational

          These are costs incurred in the day to day operation of the landfill. They include maintenance for vehicles and salaries and wages for staff. They have also been averaged out for each cubic metre of landfill space.

- All costs and benefits arising from the proposed ZWS were calculated. These are:
    - Collection costs

      As above
    - Scheme costs
        - Capital

          Cost of setting up a waste separation, sorting and storing recyclables. Included in this is the cost of a baling machine used to reduce the volumes of the separated waste
        - Operational

          Labour cost for separating, sorting and storing of recyclable fractions.
        - Marketing campaigns

          Costs incurred in running campaigns within the case study areas to promote the ZWS
        - Dual containers

          Cost of replacement of current bins with dual containers that are able to store the separated waste streams

        - Collection bags

        Cost of additional bags for the storage and collection of the recyclable waste

    - Benefits arising from
        - Sale of recyclable

        Income generated from the sale of recyclables to recyclers. High profit scenario uses the highest price for each recyclable component in the year of analysis. Low profit scenario uses the lowest price for each recyclable component in the year of analysis.

For scenario 2 and 3, the framework is as follows:

- All costs arising from the disposal of household solid waste were calculated. These are:
    - Collection costs

    These are transportation costs incurred in the collection of waste from households and transportation by the service provider to the landfill. This is inclusive of vehicle maintenance and labour costs.

    - Disposal costs
        - Capital

        These are construction costs incurred in preparing the landfill to receive waste and have been averaged out for each cubic metre of landfill space created

        - Operational

        These are costs incurred in the day to day operation of the landfill. They include maintenance for vehicles and salaries and wages for staff. They have also been averaged out for each cubic metre of landfill space.

- All costs and benefits arising from the proposed ZWS were calculated. These are:
    - Collection costs

    As above

    - Scheme costs
        - Capital

Cost of setting up a waste separation, sorting and storing recyclables. Included in this is the cost of a baling machine used to reduce the volumes of the separated waste

- Operational

Labour cost for separating, sorting and storing of recyclable fractions.

- Benefits arising from
  - Sale of recyclable

  Income generated from the sale of recyclables to recyclers. High profit scenario uses the highest price for each recyclable component in the year of analysis. Low profit scenario uses the lowest price for each recyclable component in the year of analysis.

The total cost saving (benefit) is then the difference between the total current system costs and the total ZWS system costs. This difference was then divided by the mass and volume of recycled waste in order to determine the cost saving per unit mass and per unit volume. The results from the four scenarios were then compared and conclusion reached on the economic sustainability of the proposed ZWS.

The key assumptions made in the CBA will now be discussed. These assumptions apply to all the scenarios identified in Table 4.1. Firstly, the capital costs of setting up an MRF include only additional equipment that will be utilized in setting up a pilot MRF. This means that the capital costs incurred in setting up existing facilities, which will be utilized in the MRF, have not been included. Also, the fact that the ZWS is at pilot phase means that economies of scale, in terms of a ZWS for all Durban, have been excluded from the analysis. These costs for a scaled up ZWS would only be investigated if the pilot proved successful. And it is only then that the capital costs of setting up a fully operational large scale MRF would be included in a CBA. Thus it can be seen that a pilot scale ZWS will operate under different economic conditions compared with a full scale ZWS. Economic complexities arising from economies of scale would have to be catered for in the full scale ZWS.

Secondly, the effect of the proposed ZWS on the price of recyclables is expected to be minimal. This is due to the fact the quantities of recyclables generated in the pilot ZWS will not significantly increase the total quantity of recyclables already present in the recyclables market. However, should a full scale ZWS be implemented in Durban, such an assumption would be negated as a result of the economies of scale factor raised before. Thus it is important to understand that the upper and lower limits of the price of recyclables apply only to the pilot scale ZWS. And as mentioned in previously in this Section, these limits are in place to cater for the price volatility within the recycling market. Such volatility would be expected to flatten out in case of full scale application of the ZWS. Hence it can be concluded that the effect of implementing a ZWS would be negligible at micro economic (pilot) scale, whilst it could be considerable at macro economic (full) scale.

4.4.5 Institutional assessment

While the social assessment focused attention on the ability of the households to participate in at-source separation of recyclables and engage in waste minimisation behaviour, institutional assessment focused on the supply-side aspects of the implementation and maintenance of the ZWS. These supply-side aspects focused on the ability of the eThekwini Municipality, through DSW, to effectively implement and manage the proposed ZWS. The criteria identified in Section 4.2.4, in the form of the IAD Framework, were used in this assessment. The main institution that was assessed was DSW, but where appropriate the Municipality was also assessed. Information regarding the assessment was sourced from the Integrated waste management plan for the eThekwini Municipality (SKC, 2004). The Integrated development plan (2003 – 2007) for the eThekwini Municipality and other published reports, including the Municipality's website (www.durban.gov.za), were also consulted.

4.5 Summary

In this chapter, the methodological approach used to test the applicability of the proposed Zero Waste Schemes in post-consumer waste arising from rural and urban households has been outlined. The methodological approach is based on an assessment of the proposed ZWSs using the sustainability criteria: environmental, economic, social and institutional. The models used to carry out the assessment for each criterion have been identified and the choice for each elaborated on. Although these overarching sustainability criteria have been applied to both the rural and urban case study areas, their application was different due to the fundamentally different waste management systems operating in each area. The results for this assessment will be presented in chapter 6 and 7 respectively for the rural and urban area case studies.

CHAPTER 5

5. RESULTS OF CASE STUDY 1: NDUMO

5.1 Introduction

Most municipalities in developing countries spend a large proportion of their budgets on collection, transportation and disposal of solid wastes (Altaf et al, 1996; Henry et al., 2005). Although this assertion may be appropriate for municipalities in urban areas of South Africa, it is not the case for rural municipalities as they have little or no tax base to support these services (Republic of South Africa, 2000c). The PEACE Foundation (2004) further states that unlike cities and small towns, residents of poverty-stricken rural areas do not generate any income to cover the cost of waste collection and disposal.

Since rural areas have become the responsibility of municipalities, the Local Government Municipal Systems Act (Republic of South Africa, 2000) requires the municipalities to strive to ensure that municipal services are provided to the local community in a financially and environmentally sustainable manner. Considering the common economic conditions of rural areas, municipalities cannot cope with providing these essential services (PEACE, 2004). This lack of WM services results in deterioration of the environment and standards of living, which severely threatens environmental integrity and human health (DEAT, 2000). Thus the duty of service provision in an environmentally sustainable manner is negated.

The aim of this chapter is to describe the results obtained in the application of the conceptual Zero Waste Model, which was developed in Chapter 3, in the rural area of Ndumo. Ndumo was identified as a representative case study due to the availability of resources arising from an existing 'poverty alleviation' programme promoted by the PEACE Foundation (a non-governmental organisation). The development, which is known as the Sustainable living for community development, was set up by the PEACE Foundation with the assistance of an Environmental Consultant (Ecosystems cc). The waste management project forms part of this initiative. Funding for the project, which commenced in March 2003, was provided by the Department of Environmental Affairs and Tourism (DEAT).

In terms of the layout of the chapter, Section 5.2 gives a brief description of Ndumo as well as socio-economic indicators for the area. Section 5.3 follows up with the results for the sustainability assessment of the existing waste management project in Ndumo. The results of the implementation and sustainability assessment of a proposed zero waste scheme, which follows on from the assessment of the existing waste project, are discussed in Section 5.4. A summary of the main results identified in this chapter will be given in Section 5.5.

5.2 Description of the case study area

Ndumo, with a population of around 22 500, is a small rural town situated in northern KwaZulu-Natal in the Jozini local municipality within the district municipality of Umkhanyakude (See Figure 5.1). The town is adjacent to the Ndumo Nature Reserve. A supermarket is the major business in the area and is supported by a few local stores. The local community is served by a clinic, a police station, an army base and primary and secondary schools. Like many rural towns in South Africa, Ndumo is characterized by high levels of unemployment and poverty (Green et al, 2004). According to the 2001 Census, Ndumo has an unemployment rate of 97% and 61% of households have no annual income (Stats SA, 2001). The waste management system in the area is almost non-existent, with 63% of households not having access to refuse disposal and the other 33% disposing their waste in illegal dumps (Stats SA, 2001). The other indicators for Ndumo are shown in Table 5.1.

From Table 5.1, it can be seen that the poverty rate of 69% for Ndumo is similar to the 71% which was identified for rural areas in Section 3.5.1. Similarly, the number households having access to clean water in Ndumo stands at 48%, as compared to a national average of 45%. Alarmingly, the number of households not having access to electricity stands at 95%, which is significantly higher than the national average of 62%. Also, 77% of households do not have access to toilets of any type and this is significantly higher than the national average of 26%. These highlighted figures show that Ndumo is a typical rural area in South Africa; hence the discussion of the waste management system characteristics identified in Section 3.5.1 and Section 4.3 also apply to it. This conclusion contributes significantly to the discussion on the waste project existing in Ndumo before the ZWM could be applied. The results for the waste project assessment are discussed next.

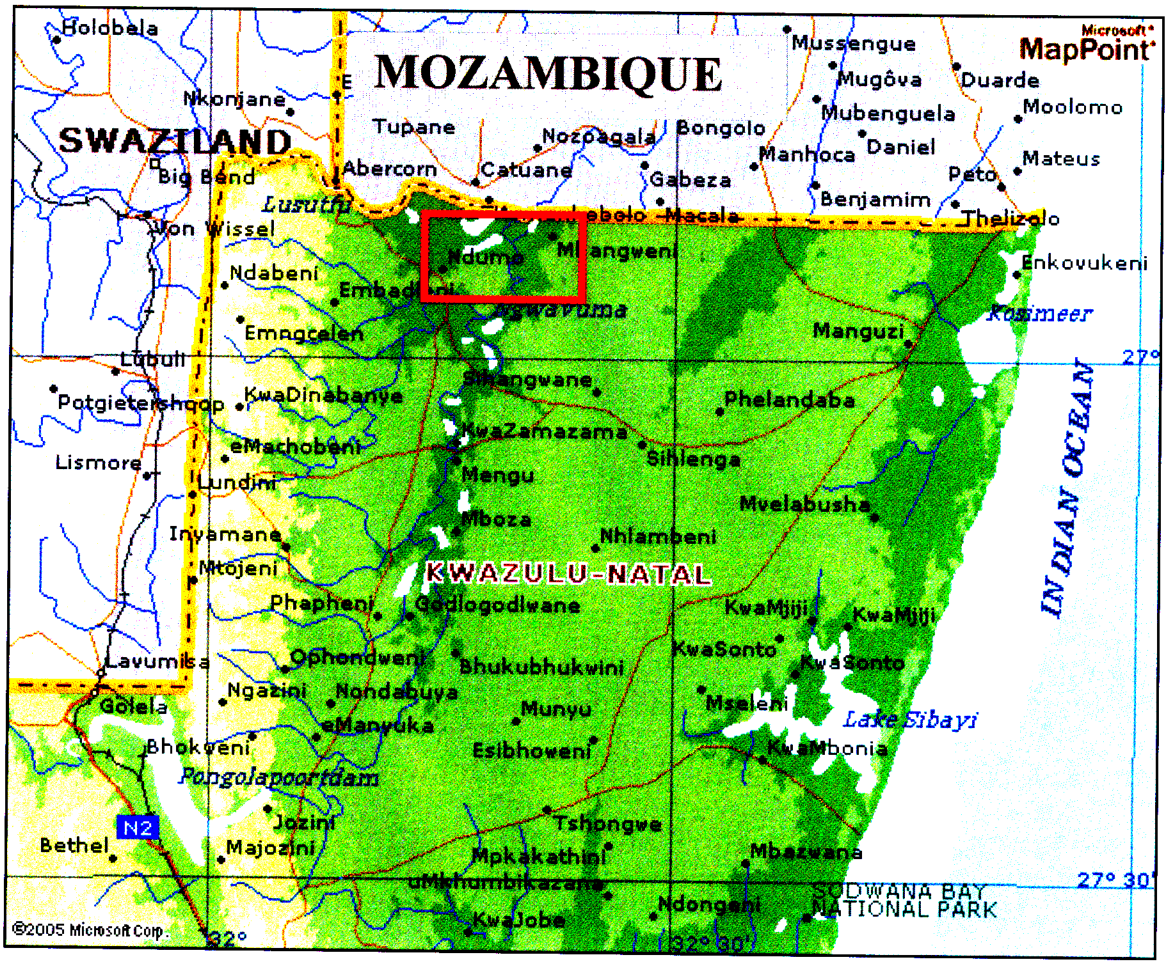

Figure 5.1 Map of Northern KwaZulu-Natal showing the Ndumo area (highlighted)
(Source: http://encarta.msn.com/map)

Table 5.1: Statistics for Ndumo (Source: Stats SA, 2001)

CATEGORY	TOTAL	PERCENTAGE (%)
Population	22 517	
Male	10 027	45
Female	12 490	55
Education		
No schooling	5 814	26
Grade 0 – 12	2 556	11
Higher	243	1
NA		62
Employment		
Employed	273	3

Unemployed	630	5
Not Economically Active	4 667	40
Transport		
Vehicles	407	2
By Foot	9 576	43
NA	12 534	55
Dwelling Type		
Formal	1 752	41
Informal	138	3
Other	2 316	56
Source of Energy		
Electricity	255	5
Candles	3 924	93
Others	63	2
Refuse		
Own dump	1 377	33
No Disposal	2 652	63
Other source	<40	<1
Sanitation		
Flush toilet	207	5
Other types	735	18
None	3 231	77
Water		
Rain Tank	2022	52
Community stand	1 497	36
Borehole at dwelling	189	1
River/stream	336	8
Annual Household Income		
None	2 547	61
R1 – R4,800	327	7
R4,801 – R9,600	654	16
R9,601 – R19,200	273	7
>R19,200	408	9

5.3 Existing waste management project

This section presents the results from the data collection and analysis outlined in Chapter 4. The results follow the order adopted in the methodology section for the rural case study in the same chapter.

5.3.1 Background information on the waste project

The Sustainable living for community development is a 'poverty alleviation' project set up by the PEACE Foundation with funding provided by DEAT. In the Business plan submitted to DEAT, the duration of the project was 49 weeks. The development was meant to have started in September 2002, but only started in March 2003. A major delay was due to the DEAT application documents being filled in improperly by the Ndumo Trust and thus having to be resubmitted (Arbuthnot, 2004). Implementation of the project was to be carried out by PEACE, with Ecosystems providing the technical services. After the stated period, the development was to be handed over to the Ndumo Community PEACE Development Trust, with PEACE assisting in the management as well as monitoring of the development. The Trust is headed up by a Board of trustees, which has fifteen members (Frost, 2004). Four of the members are women and the other members include representatives from the police force, teachers, councillors, the tribal authority, eco-tourism and environmental specialists, a nurse and other key members of the community (Frost, 2004).

The development is made up of three projects: the Organic food project; the Waste management project; and the Vukhuzakhe craft project. Both the Waste project and the Vukhuzakhe crafters are located at the community centre (see Figure 5.2), while the Organic food project is located at an environmental centre, which is located about 1.8 km from the community centre. Signage has been erected at the centre highlighting the waste and craft projects (see Figure 5.3).

The principal aims of the development were: to establish a waste management depot by refurbishing the existing community centre at Ndumo; to install a waste information system, hardware and software, to link producers of crafts to markets; to establish a community trust to manage the facility; to train and equip organic farmers, crafters, weavers, recycling and waste management operators; and to erect signage highlighting the project.

The finance for the development was provided by DEAT and totalled R600 000 for the 49-week duration. The breakdown of the budget is shown in Table 5.2. From the Table 5.2, it is clear that no other funding was sourced for the initial set up of the development. After this initial set up, donor funding was to be sourced by the PEACE Foundation. The funding was mainly to pay for workers' wages, which cost R4000 per month (PEACE, 2004). Funding was also needed for the transportation of recyclables from Ndumo to the Jozini Recycling Centre.

Figure 5.2 Ndumo PEACE Centre

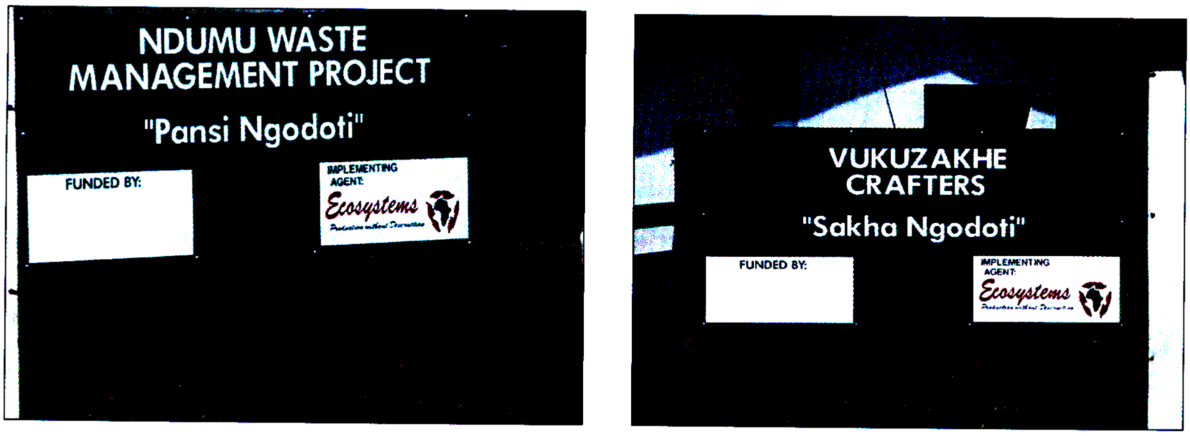

Figure 5.3 Signage at the PEACE Centre highlighting the Waste management and Craft projects respectively

writing, only the Army Base was regularly delivering waste to the community centre, while general waste from the clinic was collected directly by the waste group. The other waste producers were giving different reasons why they could not deliver waste to the centre (Gumede, 2004; Mathe, 2004). For example, the Nature Reserve would only deliver waste to the centre if the centre had approval for DEAT to operate a waste disposal facility. Since the centre did not have a permit, the Nature Reserve would not use the centre (Gumede, 2004; Mathe, 2004). As such, waste accumulated at the community centre consisted of litter collected around Ndumo, waste collected from the clinic and that delivered by the Army Base. Litter is collected by the waste group 2 – 3 times a week. It is then brought to the community centre where it is separated into recyclable and non-recyclable fractions. The recyclables are then sorted by type and colour and stored in bags. The non-recyclable fractions are burnt in an incinerator, by the waste group supervisor, with the residue being dumped in an open pit next to it. At the time that this research was done, the incinerator was not licensed to operate and consultant was in the process of applying for the operating license.

Bins have also been installed at strategic areas around Ndumo for collection of waste: two each at the three schools, three at the community centre, nine along the main road, four at the Spar and one each at the tavern, shopping centre and market. The bins are emptied at the same time as litter is being collected. Other major sources of waste are the schools in the area. Collection of waste from these is also carried out regularly. All the recyclables are stored in the waste shed at the community centre. The plan was that as soon as the recyclable bags were full, they would be transported to the Jozini Recycling Centre. Income generated from the sale of the recyclables would then accrue to the waste group. During the period that the waste project was assessed, that is until October 2004, none of the recyclables collected in Ndumo were transported to Jozini.

The craft work produced from waste (see Figure 5.4) is sold in Ndumo. No links were established to sell the craft work to markets outside Ndumo. On further investigation, the Ingwavuma Women's Centre in Ingwavuma was identified as a possible market for the craft produced in Ndumo. The centre is located about 30 km from Ndumo. Craft made at the centre is produced from sisal twine. Part of the sisal used in craft production is procured from the waste project in Ndumo; however, there is minimal use of waste material for craft (Williams, 2004), with the production of crafts being demand driven rather than supply driven. Thus, it can be concluded that the craft made from waste in Ndumo has a limited market.

In terms of finances, the waste management project is funded by PEACE. The wages of the workers and supervisor are paid directly by PEACE. Finance is also provided by PEACE for the tools and uniforms that the workers use. To this end, PEACE is in the process of securing donor funding for the waste project beyond the pilot phase.


Figure 5.4 Craft produced in Ndumo using waste materials

Community participation in the waste project is at best minimal and passive. A litter campaign had been planned for the schools in the area to raise awareness of the waste project, but the campaign did not take place. The Consultant had not consulted the Provincial Education Department and was unable to secure a school day when the campaign could be run.

Facilities

The bulk of the work for the waste group is the sorting of the waste and storage of the recyclables. This is done in a shed specially constructed for this purpose (see Figure 5.5). The shed consists of a floor slab at the centre and recyclable waste storage in bags along the periphery of the shed (see figure 5.6). The non-recyclables are incinerated in an incinerator located next to the waste shed (see Figure 5.7). According to the waste supervisor, this is done once every week. For collection purposes, two trolleys were provided (see Figure 5.8). The waste supervisor indicated that the trolleys used for waste collection were bulky and heavy, and thus difficult to pull manually along the gravel roads in the area (Gumede, 2004).

Figure 5.5 Waste shed, with waste collection trolley in the foreground

Figure 5.6 Recyclable waste storage bags

Figure 5.7 Non-recyclables waste incinerator

Figure 5.8 Waste collection trolley

Materials

The recyclable fractions are stored in bags at the community centre. The fractions are separated according to type, with some fractions being further separated by colour; especially glass, plastics and cans (see Figure 5.9). The main fractions are glass, plastics, cans and cardboard. Glass is separated by colour into clear, brown and green. Plastics are separated by type into bottles (polyethylene terephthalate, PET and high-density polyethylene, HDPE) and packaging (low-density polyethylene, LDPE). Cans are also separated by type into beverage and other types as shown in Figure 5.9.

Figure 5.9 Beverage cans and other types of cans stored separately

For the 14 months that the waste project had been in operation, the amounts of recyclable fractions collected in Ndumo were estimated. The estimated volumes are given in Table 5.3. The estimated volumes were converted into masses so as to calculate the income that could be generated from the sale of the recyclables as shown in Table 5.4. The prices used in the calculation were based on market prices for recyclable material in Gauteng and KwaZulu-Natal in 2003 (Green et al, 2004). As can be seen from Table 5.4, the income that could be generated from the sale of recyclables is insignificant; especially when it is considered that the recyclables have been collected over a 14-month period.

Skills training

With regards to the training of the workers, Ecosystems furnished a detailed training programme that the workers underwent (see Appendix A.1). According to Eischler (2004) the training involved: waste type identification; costing of waste; alternative uses of waste; compost making; basic business skills; health and safety. After training, the workers were deemed competent to carry out the required tasks of waste collection, sorting and storage of recyclables and incineration of non-recyclables. This training took place at the Zululand centre for sustainable development in Empangeni (near Richard's Bay). The centre is the training arm of Ecosystems cc.

Table 5.3: Volumes of Recyclables at Ndumo (March 2003 – September 2004)

Material	Volume (m^3)
Food cans	2.20
Glass bottles	1.95
Plastic - Bottles	2.60
Cardboard	2.36
Cans - Loose	1.80

Table 5.4: Potential income generation from recyclables at Ndumo

Material	Mass (kg)[1]	Price (R/kg)[2]	Potential Income (R)[3]
Food cans	150	0.15	22.50
Glass bottles	440	0.20	88.00
Plastic	135	0.05	6.75
Cardboard	100	0.45	45.00
Cans	320	0.65	208.00
		Total	**370.25**

1 Masses are approximated from the collected volumes in Table 4.2

2 Values approximated from Green et al. (2004)

3 Potential Income from recycled waste collected over a period of 14 months (July 2003 – Sep. 2004)

5.3.3 Sustainability assessment of waste project

As mentioned in Section 4.4.3, the purpose of the sustainability assessment was to establish the functionality of the existing waste project thus identifying whether there was a need for the ZWM to be applied in Ndumo. The sustainability assessment considered environmental, economical, social and institutional aspects of the waste project.

Environmental sustainability

In terms of operational efficiency, the waste facilities provided in the waste project are sustainable given current waste generation and utilisation of facilities by commercial waste generators. And as long as recyclables are taken off-site regularly, there will be no problems in terms of availability of storage space. Although the waste generators earmarked for the waste project are using the facilities provided, these facilities are underutilised. Also, the location of the waste collection bins on the streets around Ndumo means that most households do not use the bins. Both of the aforementioned factors imply that the waste that is meant to be collected by the project is being disposed of in the traditional way: dumping it in open pits. This dumping of waste means that there is no reduction in environmental emissions as no recycling takes place, rendering the waste project environmentally unsustainable; hence the need to apply the ZWM in the Ndumo waste management system.

Economic sustainability

Table 5.4 shows that recyclable material yields from the project are very low due to lack of support by the commercial waste generators in the area. This in turn has rendered the project financially unsustainable as income generation from the sale of recyclables is insufficient to cover the operational costs. These operational costs include the wages of the workers involved in the project and the transportation of recyclables from Ndumo to the nearest buy-back centre located in Jozini; the wages amount to R4000 per month (PEACE, 2004), while transportation costs vary between R346 – R410 for each trip to Jozini. The high transportation costs are due to the fact that Ndumo is located 70 km from Jozini, with 17 km of the trip having to be made on an untarred road. According to the project consultant, this outcome was expected as "it was never intended that a town the size of Ndumo would be able to make a substantial income from the sale of waste, rather that the services provided [were to be] paid for by the Jozini Municipality and sponsored by corporates" (DuToit, 2004). Therefore, it is clear that the Ndumo waste project cannot sustain itself financially based solely on the sale of recyclables collected at the centre.

Social sustainability

The waste management project in Ndumo is socially unsustainable. Firstly, the waste collection service provided by the project is inequitable as only commercial waste generators, who do not pay for the service, benefit from the project while households are excluded. Furthermore, the majority of the major waste generators targeted by the waste project are not utilising the service offered by the project, while households are serviced only by communal waste collection bins. Secondly the lack of waste collection services for households means that households are not experiencing direct benefits of the implementation of the project; hence their lack of environmental awareness when it comes to waste management. This negative impact of lack of collection of household waste has however been minimised by the collection of litter from streets around Ndumo. The collection of litter has resulted in a cleaner environment in Ndumo, thus enhancing environmental integrity and human health.

Institutional sustainability

As mentioned in preceding sections, there are a number of stakeholders involved in the waste project. These include: the PEACE Foundation; the Ndumo community through the Board of Trustees; the Department of Environmental Affairs and Tourism (DEAT) as the funding agency and; the commercial waste generators which include the Spar, the Army, the Police, the Clinic, the Ndumo Game Reserve and the Tembe Elephant Park. Of these stakeholders, PEACE bears the administrative burden of the waste project as it has no support from the Municipality responsible for Ndumo, while the Board of Trustees acts only in an advisory role. Without the support of the Municipality, PEACE is finding it difficult to administer as well as to secure long-term funding for the project.

With regards to the waste project, the Jozini Municipality indicated that it was responsible for providing waste collection and disposal services in Ndumo. The municipality was in the process of taking over the disposal of waste in Ndumo, with the aim of doing so without charging the waste generators until such a time that Ndumo would be declared a town and proper rates could be charged (Mngomezulu, 2004). This fact is also stated in the Integrated Development Plan (2004) for the municipality. In the meantime, the Municipality had set up the Jozini Recycling Centre, where the recyclables from Ndumo could be sold. The interaction between the Ndumo waste project and the Jozini Recycling Centre will be expounded on in Section 5.3.4.

Since rural areas are rarely able to mobilise sufficient resources to finance their own development (Republic of South Africa, 2000c), the financial burden of waste service provision in Ndumo lies with the Jozini Municipality. At the moment, however, that financial burden is completely the responsibility of PEACE since no income can be generated from waste generators in order to cover the cost of the waste project. This has meant that PEACE has had to secure funding from donor agencies, which as experience shows, is often unreliable. As PEACE (2004) asserts, "collection of waste in remote rural areas is not economically viable unless supported by donor funding."

The preceding discussion underscores the fact that without the support of the Jozini Municipality, PEACE does not have the administrative and financial capacity to carry the waste project on a long term basis. Since the Municipality is unable to support PEACE with regards to the waste project, it can then be concluded that Ndumo waste project is institutionally unsustainable. This conclusion will be emphasised again in the next section, which is a discussion on the results of the End-Life Cycle Assessment of the recyclable waste collected in Ndumo.

5.3.4 End-life cycle assessment

It was determined by the project proponents that the recyclables collected in the waste project would be transported to the Jozini Recycling Centre. From there they would be sold to various recyclers contracted by the centre. An investigation on the centre showed that two recyclers were involved in buying the recyclables collected at the centre. At the time of the investigation, however, the sale of recyclables was halted while an institutional framework for the centre was being set up (Green et al, 2004). As such, the final destination of the recyclables is unknown at present and thus the final products of the recycling process cannot be determined.

As already discussed in Section 4.4.1, none of the craft produced from waste in Ndumo was linked to outside markets. A possible lead was investigated with regards to the Ingwavuma Women's Centre, which deals with crafts. From discussions with the managers of the various sections, the conclusion reached was that there was minimal use of waste in producing craft as the process is demand driven, that is, subject to requirements by craft buyers. The discussion on the Jozini Recycling Centre further emphasis this point.

Jozini Recycling Centre

The Jozini Recycling Centre is located in the town of Jozini. Jozini is a small town located in northern KwaZulu-Natal, about 70km south of Ndumo. The Centre was set up by an international donor agency and the Provincial Environmental Affairs Department (Green et al., 2004). The objectives of the project were to alleviate poverty and create sustainable livelihoods while effecting an improvement in environmental quality in Jozini (Green et al., 2004). This means that local people were trained and employed to work at the centre, while the centre also serves as central point for the sorting and storage of recyclables collected in Jozini itself. Quantities and categories of recyclables collected at the Jozini Recycling Centre over a period of eight months are shown in Table 5.5, while Table 5.6 shows the potential income that could be generated from the sale of these recyclables. A portion of the recyclable waste is used by a team of crafters to create crafts such as bags, mats, toys and curios (Green et al., 2004).

Table 5.5: Quantities and categories of recyclables collected at the Jozini Recycling Centre over a period of eight months (Source: Abongi Bemvelo Environmental Management Services (ABEMS) (2003) cited in Green at el. (2004))

Main Categories	**Sub-categories**	**Mass (kg)**
Tins	Uncrushed beverage cans	60
	Crushed beverage cans	141.6
	Mixed beverage cans	1771.2
	Motor oil cans	577.5
	Uncrushed food cans	820.8
Cardboard	Packaging cardboard	1214
Plastic bags	Clear plastic bags	509
Plastic bottles	Plastic juice bottles	30
	Fish oil plastic	11.5
Egg container		40.2
Paper	White Paper	482.4
Glass	Green bottles	299.5
	Brown bottles	341.7
	White bottles	524.6
	Mixed bottles	317.2
	Food bottles	108
	Crushed bottles	172
	School project bottles	612
TOTAL		**8033.2**

From Table 5.6, it can be seen that the centre, like Ndumo, is not financially sustainable as the income that could be generated per month would not be able to cover the wages of the

20 workers that work there. According to Green et al. (2004), the major challenge facing the project was its long-term sustainability. The main concern was whether the centre could generate enough income to sustain the number of workers that work there, while other concerns included the quantities of recyclables required to sustain the project and the existence of a market for crafts made from waste (Green et al., 2004). There was also a question of the type of institutional set-up the project would need to adopt in order to manage its resources and to engage in commercial transactions. It was recommended by the project proponents that the sale of recyclables should be on hold while the institutional framework for the project was being set-up (Green et al., 2004).

Table 5.6: Market value of recyclable material collected at the Jozini Recycling Centre over a period of eight months (Source: ABEMS (2003) cited in Green at el. (2004))

Recyclables	**Over 8 months**	**Potential income generation per month**
Cardboard	R 438.90	R 54.86
Beverage cans	R 789.12	R 98.64
Food Cans	R 41.04	R 5.13
Motor oil cans	R 173.25	R 21.66
Paper (white)	R 385.92	R 48.24
Plastic	R 25.75	R 3.22
Glass	R 285.00	R 35.63
TOTAL	**R 2138.98**	**R 367.35**

The following recommendations were made in order to resolve the long-term sustainability of the Jozini Recycling Centre (Green et al., 2004):

a) The centre should become a regional hub where recyclables from the towns in the surrounding areas could be brought and from there collected by commercial recycling companies based in Richards Bay. These would require setting up satellite buyback centres in these towns and would provide opportunities for entrepreneurs. Recyclables could also be obtained from game lodges and other resorts in the area.

b) Due to the size of the property where the centre is located, the potential for growth through the expansion of the agricultural component of the project should be explored. There is sufficient space and facilities to establish a diverse range of agricultural activities including market gardening, fruit tree orchards, indigenous plant nursery, poultry and pig-rearing. Chicken manure could be added to the composting process while vegetable waste could be used to feed the pigs.

c) To address the issue of an appropriate institutional set-up, a Trust should be formed to manage the centre. The Trust would be responsible for managing the project's human and financial resources and engage in commercial transactions.

Since there is potential for the Jozini Recycling Centre to be sustainable in the long-term, it follows that the sale of recyclables from Ndumo to the Jozini Centre would also be sustainable. Nevertheless, the sale of the recyclables would not render the Ndumo project financially sustainable.

5.3.5 Waste project summary

Ndumo is a rural area where a waste management project has been set up by an NGO (PEACE). An assessment of the project indicates a number of problems: waste collection services are not being provided to households in the community; the project is financially unsustainable in both the short and long term; there is reluctance on the part of commercial waste generators in the area to support the project and; institutional arrangements within the Jozini Municipality to take over and administer the project are lacking.

Even though the project has problems, it has also had a positive impact on the Ndumo community. These include: provision of waste management facilities in Ndumo, even though the facilities are used by some of the commercial waste generators only, and hence, are underutilised; collection of litter in the area, leading to a cleaner environment; skills impartation for the community members involved in the project; creation of environmental awareness within the community even though households are not involved in the project.

The case study presented in this chapter is typical of poverty relief projects funded by DEAT. An assessment of these projects shows that most of them are financially unsustainable (DEAT, 2005). This means that once the funding from DEAT ceases, the projects cannot continue. Donor funding is required to continue the projects. In the specific instance of waste projects in rural areas, where unemployment and poverty are on the increase, households in these areas are unable to pay for basic services such as waste collection and disposal. And although municipalities have plans in place to provide these services, financial constraints make it almost impossible to do so. Even when pilot projects have been started by NGOs, municipalities still experience difficulties in assuming responsibility for the continuation of the projects.

It is important to note that the problems experienced at small rural communities are not unique to any country, but are in many instances common for all developing countries (Otto et al, 2002). Otto et el (2002) further point out that financial constraints are in many instances one of the main stumbling blocks to the delivery of environmentally sound waste management services. Therefore the Ndumo waste management project is not unique, but is typical of rural area waste projects in developing countries.

From the preceding discussion, it can be concluded that the waste management project implemented in Ndumo is environmentally, economically, socially and institutionally unsustainable; hence there is a need for application of the ZWM in Ndumo. The results of the application of the ZWM will be discussed in the next section.

5.4 Proposed zero waste scheme

It was with an understanding of the waste project underway in Ndumo that a pilot zero waste scheme (ZWS) was proposed. The setting up of a project was envisaged to take place in three major stages. Firstly, a round-table discussion with all the stakeholders that would be involved in the ZWS was planned to take place in Ndumo. The proposal for the pilot scheme would be sent to all the stakeholders beforehand so that the discussion would take place at an equal level for the participants. All the possible approaches to the pilot scheme would be included in the brief for the roundtable discussion. The Participants were to be:

a. C.R.E.C.H.E. (University of KwaZulu-Natal) as the project proponent
b. The PEACE Foundation as the implementing agency
c. The Jozini Municipality as the funding agency
d. The Board of Trustees (on behalf of the Ndumo Community)
e. The Commercial waste generators (Spar, the Army, the Police, the Nature Reserve, the Clinic and the Schools in the area)

Once the scheme has been approved by the roundtable participants, the physical set up would then be carried out with the help of a C.R.E.C.H.E. (UKZN) representative who would be stationed on site for a period of a few months to make sure that the scheme got off the ground and that teething problems were addressed promptly. At the same time, an educational campaign would be set up in the schools to facilitate community awareness by educating the youth and women. The youth and women would be targeted at they were the most likely to be responsible for waste collection and disposal in the households.

After the initial period setting up the project, a time frame would then be agreed between C.R.E.C.H.E. (UKZN) and the PEACE Foundation for monitoring and evaluation of the project. The administrative and financial responsibility of the Ndumo ZWS was to be borne by the Jozini Municipality. The ZWS would be based on the ZWM developed in Chapter 3 and outlined in Figure 3.2

The proposed project would be set up as follows:

a. Measurement of the total mass of waste generated by each household in Ndumo and a waste stream analysis to determine the proportions of recyclables contained in the generated waste.
b. Instilling waste minimisation and recycling behaviour among households. Recycling would include at-source separation of purtriscible and recyclable waste.
c. Determining the frequency of waste collection needed for households and the commercial waste generators.
d. Determining the number of people that would be needed to carry out waste collection, separation and storage of the recyclables.
e. Determining the price for recyclables paid at the Jozini Recycling Centre and the actual transportation costs to the centre using different types of vehicles in order to determine the most cost-effective vehicle type.
f. Determining the number of converters that would be accessible to Ndumo and the types of recycled products made by these converters and whether such products could be reintroduced into Ndumo. The reintroduction would be coupled with an educational campaign to encourage the Ndumo community to buy the recycled products.

g. Conduct a public participation survey among the residents of Ndumo by use of questionnaire to assess the social dynamics associated with the proposed ZWS and implementation of the scheme based on the results of the survey.
h. Set-up an institutional framework within the Jozini Municipality to implement the proposed ZWS.

Due to lack of finances, the implementation of the ZWS in Ndumo could not be undertaken. However, a theoretical assessment of the sustainability of the proposed scheme can be conducted. The assessment follows on from that of the existing waste project in Ndumo.

5.4.1 Environmental Analysis

In contrast to the waste project in Ndumo, the proposed ZWS would incorporate households in Ndumo. Since waste generation rates and waste stream analysis were not conducted in Ndumo, estimations had to be made in order to determine these variables. Extensive literature research for waste generation rates in rural areas yielded no results. However, the research showed that waste generation rates for high density low-income urban areas ranged between 0.15 – 0.5 kg/person/day (DEAT, 2000). Since Ndumo is a low-income area, it was taken that these waste generation rates would be appropriate to use in the analysis. Furthermore, the study on the urban areas showed that waste arising for these areas had a high organic residue and ash content (60 – 70%) and a relatively low percentage of recyclables (DEAT, 2000).

The aforementioned discussion yielded three scenarios for testing. Scenario 1 represents the lowest waste generation rate of 0.15kg/person/day and two possible waste recycling rates: 20% and 30%. Scenario 2 represents the median waste generation rate of 0.33kg/person/day, also with the two recycling rates and Scenario 3 represents the highest waste generation rate of 0.5kg/perso/day also with the two recycling rates. The two recycling rates were chosen on the basis of the recyclable content of the waste generated in low income areas. The 20% recycling rate assumes that half of the waste fraction not containing organics and ash can be recycled when organics and ash account for 60% of the generated waste. Conversely, the 30% recycling rate assumes that all of the waste content not containing organics and ash can be recycled. The results for Scenario 1 are shown in Tables 5.7 and 5.8 for 20% and 30% recycling rates respectively. The overall results for the three scenarios are summarised in Table 5.9.

Table 5.7: Waste generation and recyclables yield for ZWS (Scenario 1 – 20% recycling rate)

Description of Calculation	Quantity	Units
Assume waste generation rate	0.15	kg/person/day
Population	22500	people
Total household waste	3375	kg/day
Total household waste (taking a 30 day month)	101	tons/month
Assume a recycling rate (20%)	0.2	
Recyclable yield	20	tons/month

Table 5.8: Waste generation and recyclables yield for ZWS (Scenario 1 – 30% recycling rate)

Description of Calculation	Quantity	Units
Assume waste generation rate	0.15	kg/person/day
Population	22500	people
Total household waste	3375	kg/day
Total household waste (taking a 30 day month)	101	tons/month
Assume a recycling rate (30%)	0.3	
Recyclable yield	30	tons/month

Table 5.9: Summary of Recyclables Yield for ZWS (All Scenarios)

Scenario	Recyclable yield at 20% [tons/month]	Recyclable yield at 30% [tons/month]
1	20	30
2	45	67
3	68	101

It can be seen from Table 5.9 that the overall recyclables yield ranges between 20 - 68 tons/month when considering a 20% recycling rate and between 30 - 101 tons/month for the 30% recycling rate. These yields are much higher than those generated by the Ndumo waste project and the Jozini Recycling Centre (see Sections 5.3.2 and 5.3.4 respectively), making it highly likely that the ZWS will be financially sustainable based on the sale of the recyclables. Whether a market exists for these recyclables cannot be determined at present. This issue of economic sustainability will be analysed in depth in Section 5.4.2.

The qualitative analysis of the proposed ZWS shows that the scheme will enhance the environmental aesthetics of Ndumo given that waste collection will also include households. The inclusion of households will lead to increased awareness about waste management issues, making it highly likely that households will continue to support the ZWS. This will be an important outcome given that the ZWS will not be sustainable without the participation of households. The other added benefit of the ZWS will be litter abatement, a function which is already being achieved in the Ndumo waste project. Overall, the inclusion of households in the ZWS will make it easier for all household waste to enter the formal waste stream. This inclusion will enhance environmental protection since disposal of waste in any uncontrolled manner will be minimised.

Since Ndumo is a rural area with ample space, the non-recyclables arising from the ZWS implementation, which include organics and ash, can be composted within the yard of each households. This compost can then be used in gardens within the homesteads and in the Organic food project and subsistence farming activities in Ndumo, leading to increased crop production and thus contributing to food security in the community. The organics arising from commercial waste generators can be composted at the community centre and then used for agricultural purposes in and around the centre.

It has been shown in this section that environmental sustainability is possible with the implementation of the ZWS. What remains to be seen is whether the ZWS can be economically sustainable. This issue will be addressed in the next section.

5.4.2 Economical analysis

This economical analysis builds on the results obtained in the preceding environmental analysis and takes into consideration that households will not be charged for the service. This issue is summarised in DEAT (2000), which states that the demand for waste management services, and the willingness and ability to pay for a particular level of service, is influenced by economic context of an area. As discussed in Section 5.1, rural households are generally unable to pay for such services. Hence the ZWS will have to be financially sustaining in order for its implementation in Ndumo to be successful.

The three scenarios investigated in Section 5.4.2 were also assessed from the viewpoint of economic viability. For each scenario, the proportions and prices from Table 5.4 were used to calculate the potential income that could be generated from the sale of the recyclables. The results for Scenario 1 with a 20% recycling rate are shown in Table 5.10, while the summary for all scenarios is shown in Table 5.11.

Table 5.10: Recyclables proportions and potential income generated from proposed ZWS for Ndumo (Scenario 1- 20% recycling rate)

Material	Proportions	Mass (kg)	Value (R/kg)	Potential Income
Food cans	0.13	2633	0.15	R 394.88
Glass bottles	0.38	7695	0.20	R 1,539.00
Plastic - bottles	0.09	1823	0.05	R 91.13
Plastic - packaging	0.03	608	0.05	R 30.38
Cardboard	0.09	1823	0.45	R 820.13
Cans - loose	0.01	203	0.65	R 131.63
Cans - compacted	0.27	5468	0.65	R 3,553.88
TOTAL	**1.00**	20250		**R 6,561.00**

Table 5.11: Summary of Potential Income generated by implementation of ZWS (All Scenarios)

Scenario	Potential Income [R] (at 20% Recycle Rate)	Potential Income [R] (at 30% Recycle Rate)
1	6561	9842
2	14434	21651
3	21870	32805

From Table 5.11, it can be seen that the potential income generated by sale of recyclables ranges between R6561 – R21870 for the 20% recycling rate and between R9842 – R32805 for the 30% recycling rate. When this income is compared with the costs of the worker's wages (R4000 per month) and for the transportation of the recyclables to Jozini (R346 – R410), it is clear that the proposed ZWS can be economically sustainable. The transportation costs take into account that the number of trips to Jozini will increase in proportion to the mass of recyclables collected in the ZWS. Conversely, the start-up of the ZWS will require external funding much like the Ndumo waste project. It is this funding that is unavailable from the Jozini Municipality. Coupled with this lack of funding is the availability of markets for the recyclables that will be sent to Jozini from Ndumo. Hence, it can be concluded that though the ZWS can be economically sustainable once it is implemented, subject to availability of markets and stability of the prices for recyclables; its initial setup is economically not feasible without the financial involvement of the Municipality or funding from donor agencies.

5.4.3 Social analysis

Characterised by inadequate water and sanitation, an unmanageable road and poor communication facilities, infrastructure in Ndumo drastically needs improvement (Thoeresz, 2004). As a result, residents of Ndumo place a very high expectation on getting a tarred road above all other infrastructural needs. Therefore the implementation of a ZWS in the area may be viewed as less important, which implies that residents may not be enthusiastic in their support of the proposed ZWS. This might render the project unsustainable in the short term, but these attitudes towards waste management can be positively influenced through community environmental awareness and education programmes (DEAT, 2000). DEAT (2000) further adds that such campaigns must be based on sound understanding of the social and cultural characteristics of the Ndumo community. This step can be carried out using questionnaires and stakeholder analysis once it is has been established that the ZWS will be implemented; otherwise expectations of the community will be raised unnecessarily and may even lead to negative attitudes towards waste management should the ZWS not be implemented within the timeframes agreed with the community. Such an outcome will threaten the social sustainability of the proposed ZWS.

The other part of the social analysis involves the provision of waste management services in an equitable way in Ndumo. The equitability of the application of the ZWS will be achieved through the provision of waste collection services to both households and commercial waste generators. This provision of a collection service is expected to promote a culture of ownership of the waste management system among households, and equally important, to improve the social status of the workers involved in the waste system. This social upliftment is one of the core expectations of a sustainable waste management system (DEAT, 2000), which looks at improving the ability of the waste workers to access social services. This accessibility to social services is also expected to improve with increased wages as more and more households participate in the scheme, leading to increased recycling rates and income that could be generated from the sale of recyclables.

The sale of recyclables, however, is dependent on the institutional set up of the ZWS. This set up will be analysed in the next section.

5.4.4 Institutional analysis

This institutional analysis of the proposed ZWS will focus on two main institutions: the Ndumo Development Trust and the Jozini Municipality.

From the discussion of the Ndumo waste project, it is evident that the Ndumo Trust does not have the economic and administrative capacity to manage the implementation of the ZWS on its own. Even with the support of PEACE, the Trust can reasonably be expected to attain administrative but not economic efficiency. In terms of equity, the provision of a waste management service through the implementation of the ZWS will achieve distributive but not fiscal equity since the primary beneficiaries of the ZWS will not bear the cost of implementing the scheme. Furthermore, the Trust would not be accountable as it lacks both the finance and management skills to implement the ZWS on its own; and finally, the Trust would not be able to adapt easily to the changing requirements of the ZWS given its technical nature. This means that the Trust would also not be able to meet the requirement of adaptability for the institutional set up of the ZWS.

The preceding discussion shows that the Ndumo Trust would not be able to meet the institutional sustainability requirements of implementing the ZWS. However, these constraints can possibly be overcome by the involvement of the Jozini Municipality in the implementation of the ZWS. Such an involvement would be in the form of financial support for the set up of the ZWS and development of managerial skills within the Trust in order to build the Trust's capacity to manage the ZWS once it has been set up. Although the financial support will lead to efficiency of the ZWS, it will lead to distributive but not fiscal equity. This is due to the fact that households in Ndumo will be provided with a waste collection service while they are unable to pay for the service, which implies that the service will be subsidized by other households within the Jozini Municipality.

In terms of the accountability principle, it will be difficult for the Ndumo Trust to hold the Jozini Municipality accountable as it will be dependent on the financial support of the municipality. The involvement of the PEACE Foundation could possibly reduce this lack of accountability, even though it will be limited. Finally, it can be concluded that the lack of support for the Ndumo waste project by the Municipality and the lack of funding to support the implementation of the ZWS means that the Municipality cannot fulfil the adaptability requirement of the institutional assessment. Although both accountability and adaptability will be marginal within the Municipality should the ZWS be implemented in Ndumo, it does not mean that the Municipality will be institutionally unsustainable. As noted by Yandle (2007), it is a rare institution that will perform well on most or all of the institutional assessment criteria as the criteria are often contradictory.

It can be noted from the discussion of institutional sustainability that it is a major constraint in the implementation of the ZWS in Ndumo. This constraint is in terms of financial requirements and administrative capacity required from the Municipality and the Ndumo Trust respectively. Apart from this constraint, it has been demonstrated in this chapter that the implementation of a ZWS in Ndumo is possible, and that this implementation will be sustainable overall if households in Ndumo are involved in the scheme. The implications of this conclusion will be discussed in Chapter 7 where they will be used to propose policy that can be implemented in rural areas in order to achieve zero waste.

5.5 Summary

In this chapter, the results of the application of a ZWM in the rural area of Ndumo have been presented and analysed. It has been shown that Ndumo is a poverty-stricken area where no waste collection services for households exist. There is a waste management project that has been implemented in the area, but its focus is on providing waste collection services to commercial establishments in the area. A sustainability assessment of the waste project shows that it is unsustainable. However, some of the facilities provided by the project can be used in the implementation of a zero waste scheme. The ZWS targets households in terms of waste management service provision, and is aimed at achieving zero waste within the post-consumer waste generated in Ndumo. Implementation of the ZWS could not be carried out due to lack of funding for the project; funding which is negatively impacted by lack of markets for recyclables. A theoretical sustainability assessment of the ZWS shows that the scheme would be sustainable, though institutional sustainability would be the major constraint in its implementation. Furthermore, the willingness of households to participate in the proposed ZWS has not been assessed given the socio-economic conditions in Ndumo. Given the sensitivity of such an exercise, it is intended that it would be conducted once it is clear that the Jozini Municipality would be willing to fund the implementation of the ZWS. This funding is not available at the moment. As mentioned earlier, the implications of the ZWS sustainability assessment will be discussed in Chapter 7. The next chapter will, however, be a presentation and discussion of the results of the application of the ZWM in an urban area.

CHAPTER 6

6. RESULTS OF CASE STUDY 2: DURBAN

6.1 Introduction

Waste management, in terms of collection and disposal, is well established in the urban areas of the eThekwini Municipality and households are able to pay for such services. However, the waste management system exhibits different levels of service within the municipality. The Local Government Municipal Systems Act (Republic of South Africa, 2000) was enacted to address this imbalance in service delivery. The Act requires that municipalities strive to ensure that municipal services are provided to local communities in a financially and environmentally sustainable manner, and that local communities have equitable access to such services. In terms of integrated waste management, the eThekwini Municipality is striving to fulfil these requirements through the implementation of their IWMP (eThekwini Municipality, 2003).

The aim of this chapter is to describe the results of the application of the zero waste model (ZWM) into an already established integrated waste management system. The waste management system is operated by Durban Solid Waste (DSW) as part of the eThekwini Municipality.

The chapter comprises of eight main sections. A brief description of the case study areas selected for the investigation is given in Section 6.2, while Section 6.3 is a discussion on the proposed zero waste scheme (ZWS). An assessment of this proposed ZWS, in terms of environmental, social, economic and institutional sustainability, is carried out in Sections 6.4, 6.5, 6.6 and 6.7 respectively. A discussion on the main findings is carried out in Section 6.8 and the chapter concludes with a summary in Section 6.9.

6.2 Description of case study area

Mariannhill Park and Nazareth are two communities located adjacent to the Mariannhill Landfill site as shown in Figure 6.1. The landfill site is located about 20km west of the Durban CBD (central business district). The area forms part of the Inner west region of the eThekwini Municipality. According to a study conducted by SKC (2002a), the Inner west region makes up 11.2% of the total area of the municipality, with a population size of 631 705 (20.6% of the total municipal population). Housing in these areas is sub-divided into formal and informal, with 74% of residents living in formal housing and 26% in informal housing (SKC, 2002a). Residents in formal housing generate 95% of the domestic waste in the Inner West Region, while those of informal housing generate 5% (SKC, 2002a).

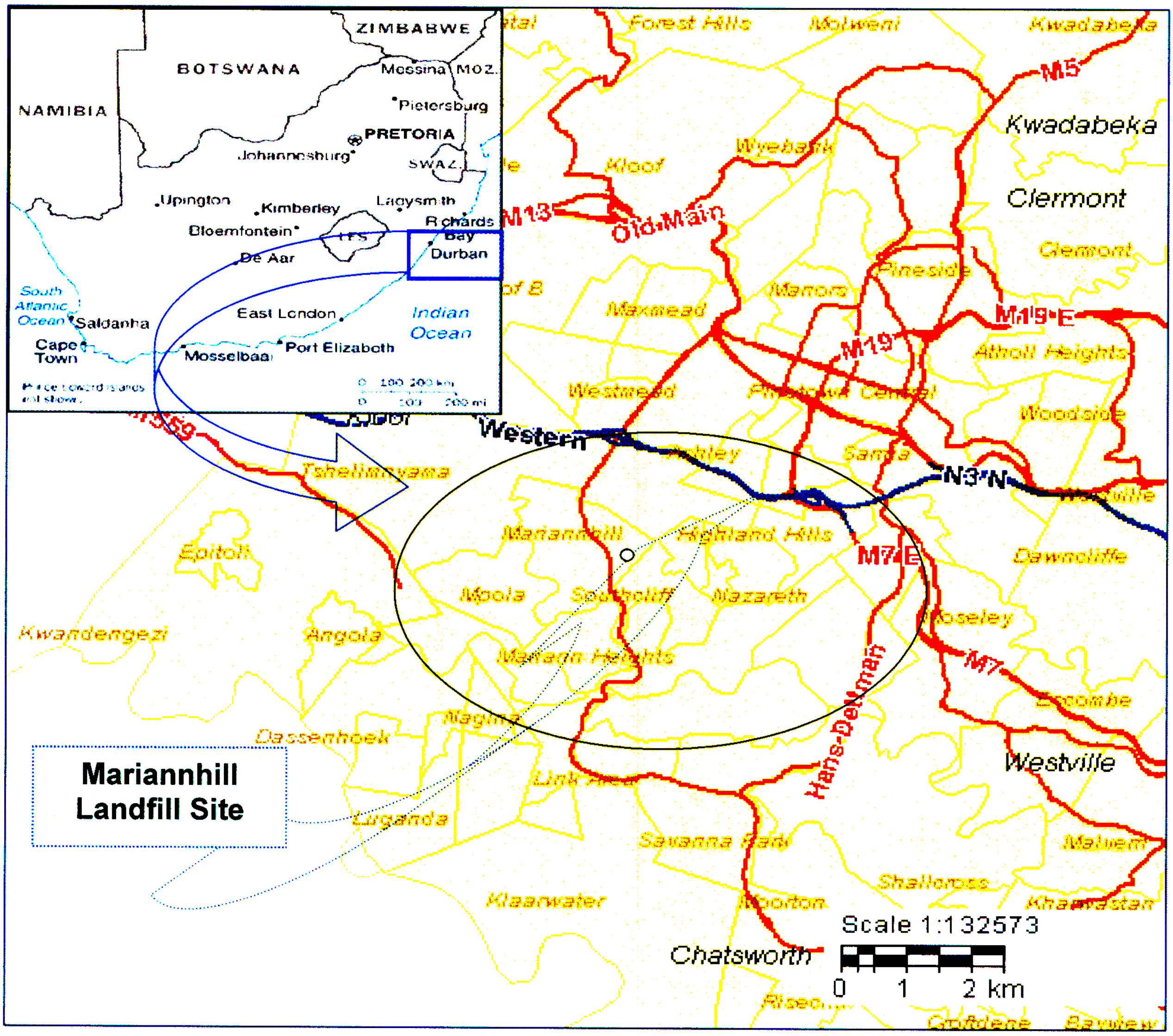

Figure 6.1 Map of eThekwini Municipality showing the Mariannhill and Nazareth areas (highlighted) (Sources: http://geography.about.com/library; http://www.sa.c2a.c.az)

6.2.1 Mariannhill Park

According to statistical data from eThekwini Municipality (2007), Mariannhill Park is an upper-middle income area, where 73% of households earn more than R38400 per annum. With about 3000 housing units (Marshall, 2005), the area has mainly formal housing, which accounts for 76% of housing in the area. The population is estimated at 12300 given that the average household occupancy is 4.1 people/household (Stats SA, 2001). A typical house in Mariannhill Park is shown in Figure 6.2. Kerbside collection of the generated waste is provided by DSW using Rear-End loading trucks, with waste being collected once a week and each household being provided with 2 x 85 Litre collection bags; additional bags can be purchased from DSW if required. The generated waste has a density of 90 – 125 kg/m^3 (SKC, 2002a). This waste accounts for 0.4% of the total waste generated in the eThekwini Municipality.

Figure 6.2 Typical house in Mariannhill Park

6.2.2 Nazareth

Nazareth is a lower-middle income area, where 52% of households earn less than R19200 per annum (eThekwini Municipality, 2007. With about 1250 housing units (Marshall, 2005), the area has mainly formal housing, which accounts for 88% of housing in the area. The population is estimated at 4910 given that the average household occupancy is 3.9 people/household (Stats SA, 2002). A typical house in Nazareth is shown in Figure 6.3. Kerbside collection of the generated waste is provided by a waste contractor who is subcontracted by DSW, with waste being collected once a week and each household being provided with 2 x 85 Litre waste collection bags per week; additional bags can be purchased from DSW if required. The generated waste has an average density of 200 kg/m^3 and a maximum of 300 kg/m^3 (SKC, 2002a). This waste accounts for 0.09% of the total waste generated in the eThekwini Municipality.

Figure 6.3 Typical house in Nazareth

6.3 Proposed zero waste scheme

It has been shown in the development of the ZWM, in Chapter 3, that zero waste in post-consumer waste can be achieved through application of waste minimisation and recycling, with at-source separation. Ideally, waste minimisation reduces the amount of waste needing disposal, whilst simultaneously increasing the fraction of recyclables within the generated waste stream. As Barr et al. (2001) and Tonglet et al. (2004) have hypothesised, waste minimisation is likely to be influenced by concern for the environment and the community, while perceptions of inconvenience and lack of time and knowledge are likely inhibitors. Given that these concerns cannot be easily addressed in the short-term, it follows then that waste minimisation is the long-term goal of the ZWS. This means that promotional and educational campaigns should be designed and implemented with a goal of influencing households towards waste minimisation behaviour.

Currently though, recycling forms the thrust of the implementation of the ZWS since it is much easier to implement and much more understood by householders compared with waste minimisation (Matete and Trois, 2006). Consequently, the bulk of this proposed ZWS focuses on recycling and how it can be applied to the case study areas. The assessment of this application, based on the sustainability criteria, will be carried out in subsequent sections. As shown in DEAT (2000b), prior to implementation of a recycling scheme, a detailed evaluation of the economic, environmental and social impacts should be made. A fourth factor, namely institutional impacts, has been added to the evaluation criteria.

6.3.1 Recycling

In terms of the recycling scheme design, Martin et al. (2006) show that recycling schemes should be based on the following considerations: characteristics and needs of the community; quantity and composition of the generated waste; whether participation will be mandatory or voluntary; the range of materials required and the degree of sorting; whether a collection or storage container is provided free of charge; and the day of collection and frequency of collection. DEAT (2000b) states that one approach will not necessarily meet all these requirements, so for the South African situation, Paschke and Hatcher (1991) give the following recommendations for a recycling scheme: the recommended scheme needs to be convenient for householders; it should involve little change to the present system as possible; should be practical from the view point of the service provider and; an initial education campaign to introduce the scheme to householders is required as well as an ongoing educational programme to sustain the scheme.

Given the aforementioned factors, it is proposed that a recycling scheme comprising of Mariannhill Park and Nazareth should operate as follows:

1) Paper, plastics, glass and cans should be recycled and deposited into a compartmentalised container; one compartment for recyclable and the other for general household waste
2) Participation, though it will require enforcement, should be mandatory and households should be provided with the bins for separation and extra bags for collection of recyclables, and dedicated by-laws need to be drafted to enforce recycling
3) Collection of recyclables should be on the same day as collection of general waste and collection costs should be borne by DSW

4) Marketing or public awareness campaigns should be designed and implemented within the case study areas to introduce the scheme and ongoing campaigns should be designed and implemented to encourage on-going participation in the scheme
5) A toll-free hotline should be set-up by the Municipality in order to deal with an issues arising from the implementation and running of the scheme

6.3.2 At-source separation

The recycling scheme is also based on a wet/dry model, also known as binary sorting (Martin et al., 2006), for separation of waste at source. This means that the waste would be separated into wet and dry fractions by households. Different coloured bags, as well as a compartmentalised container to store them, would be provided for household storage of each fraction. The two fractions would not be allowed to mix as in current waste collection methods where general waste and garden refuse are mixed at collection. Although at-source separation has possible disadvantages of inconvenience of time and space on households, the yield of recyclables and their quality are higher than any other methods of collecting recyclables from general household waste (Paschke and Hatcher, 1991; Tonglet et al., 2004). And because separation occurs at source, householders are made aware of the environmental implications of their decisions (Paschke and Hatcher, 1991). It should be noted that the involvement of households in source-separation of the recyclables is critical to the success of the recycling scheme (Hummel, 2000).

6.3.3 Collection

According to González-Torre and Adenso-Díaz (2004), there are two main types of collection systems that exist for recyclables: kerbside and drop-off. In kerbside collection, the recyclables, in clearly identified bags, are placed on the kerb awaiting collection by the service provider (Paschke and Hatcher, 1991). Although it is the costlier system, compared with drop-off, it is the most convenient for households and ensures a high participation rate (González-Torre and Adenso-Díaz, 2004). Conversely, drop-off is less costly than kerbside (González-Torre and Adenso-Díaz, 2004), but requires households to transport the recyclables to a central point within their area (Paschke and Hatcher, 1991). des Ligneris (2000) and Ridl (2003) note that impact of this system on the waste stream is generally limited. Since kerbside is the current collection method in the case study areas, it is proposed that the collection of recyclables should employ the same method.

6.3.4 Separation, sorting and storage

It was proposed that part of the area forming an available transfer station at the Mariannhill landfill site should be used for separating, sorting and storing of the recyclables collected from the case study areas. The area allocated for the materials reclamation facility (MRF) is approximately 300 – 360 m^2. As seen in Figure 6.4, which shows a pilot MRF at Mariannhill, the upper level of the area would be used for offloading and sorting the recyclables, while the lower level would be used for the skips that would be used to store the separated recyclables. The MRF would be covered and an electrical baling machine provided for reducing the volumes of the separated recyclables. Operation of the MRF will be labour intensive as part of the drive for job creation.

Figure 6.4: Waste Transfer Station at Mariannhill Landfill

The actual process would be as follows: separating the recyclables manually into the different categories, that is, glass, paper, plastic and cans; sorting of each category into the different grades/types; bailing of the different grades and storage in skips awaiting collection by recyclers; skips collected by recyclers when they are full for transportation to depots, with recyclers being notified when skips are ready for collection. The recyclers identified for the scheme are:

1) Cans - Collect-a-Can
2) Glass - Nampak Recycling / Reclamation Group
3) Paper - Mondi / Nampak Recycling

4) Plastic - Nampak Recycling / Reclamation Group

Contracts for collection of and payment for recyclables would need to be negotiated between DSW and each recycler.

6.3.4 Educational campaign

As noted by Martin et al. (2006), the implementation of a recycling scheme must be accompanied by sufficient publicity and promotion in order to educate the community about how and when to use the scheme. Publicity and promotion are crucial as their success directly affects the participation rate of the community in the proposed scheme. As mentioned in Section 6.3, the short-term goal of the publicity campaigns should be to encourage recycling using at-source separation, while the long-term goal is to encourage waste minimisation behaviour by the community. The campaigns, which are planned to be conducted by the waste minimisation and recycling division of DSW, should focus on getting the right information about the recycling scheme to households at the appropriate time. This will require presenting recycling as something of relevance and worth to the households involved (Paschke and Hatcher, 1991). The major aims of the campaigns should include: explaining recycling from a life cycle perspective, that is, the entire process from separation, collection, sorting, transportation to recyclers and conversion to new products; motivating households towards the three R's – reduction, reuse and recycle and; explaining the new waste management system to the households and defining what is required of them in a clear, generally understandable and neutral way (Paschke and Hatcher, 1991). In the long-run, the schools' educational curricula will have to be amended in order to reflect waste minimisation and recycling approaches to waste management as suggested by DEAT (2000b). The long-term success of the recycling scheme would also need ongoing educational campaigns of the general public/communities by the municipality.

6.4 Environmental assessment

This section presents the results of the environmental assessment of the application of the proposed ZWS in Mariannhill Park and Nazareth. The results of the waste data analysis are presented in Section 6.4.1, the recyclable quantities in Section 6.4.2, while the landfill space saving that could be achieved due to non-disposal of the recyclable quantities calculated in Section 6.4.2 is given in Section 6.4.3. While the results for Mariannhill Park and Nazareth are discussed separately in Sections 6.4.1 – 6.4.3, the end-life cycle analysis is for the recyclables arising from both areas.

6.4.1 Waste data analysis

The results of the waste data analysis are presented in this section for both case studies.

6.4.1.1 Mariannhill Park

The waste data for Mariannhill Park is shown in Table 6.1 for a five year period (2000 - 2004). It can be seen from the table that the total waste produced in 2000 is the highest of the years analysed and also shows the greatest variability within the monthly totals. The lowest total is for 2003, which has a co-efficient of variation of 0.10. It can also be seen that the monthly averages between March and August 2000 are much higher than for all the other years during the same period. This anomaly can be clearly seen when the data is presented graphically in Figure 6.5.

Table 6.1: Estimated domestic solid waste (kg) generated in Mariannhill Park (2000 – 2004) (Source: DSW (Marshall, 2005))

	2000	**2001**	**2002**	**2003**	**2004**
January	105785	91161	106781	87734	82799
February	84192	89524	83712	64127	77376
March	129894	83563	80177	74440	84559
April	112870	90506	92505	73062	72073
May	106623	87180	87832	75384	75032
June	121042	75946	75811	69197	74875
July	108339	85607	92445	77811	68651
August	121176	91876	81735	71107	84401
September	81091	81997	83263	80005	89068
October	82514	98085	95254	84768	85023
November	91861	99209	65363	72658	92148
December	93539	106137	117379	91509	107799
Total	**1238925**	**1080790**	**1062257**	**921803**	**993803**
Mean	**103244**	**90066**	**88521**	**76817**	**82817**
Std. Dev	**16493**	**8236**	**13842**	**7979**	**10575**
Co. Var.	**0.16**	**0.09**	**0.16**	**0.10**	**0.13**

The F-statistic was used to test whether this anomaly had any significant effect on the yearly averages and the seasonal averages. The results of the F-stat are given in Tables 6.2 and 6.3 for the yearly and seasonal comparison respectively. Both results show that there is no significant difference, at a 95% Level of confidence, in the yearly and seasonal means between the five years analysed. Also, waste generation data for 2003 and 2004, the years used in the analysis of the proposed ZWS, shows little variability within the monthly totals as shown in Figure 6.6, while there is an increase of about 8% from 2003 to 2004 in total waste generated. Finally, using data from the two years, waste generation rate increased from 25.6 to 27.6 kg/household/month.

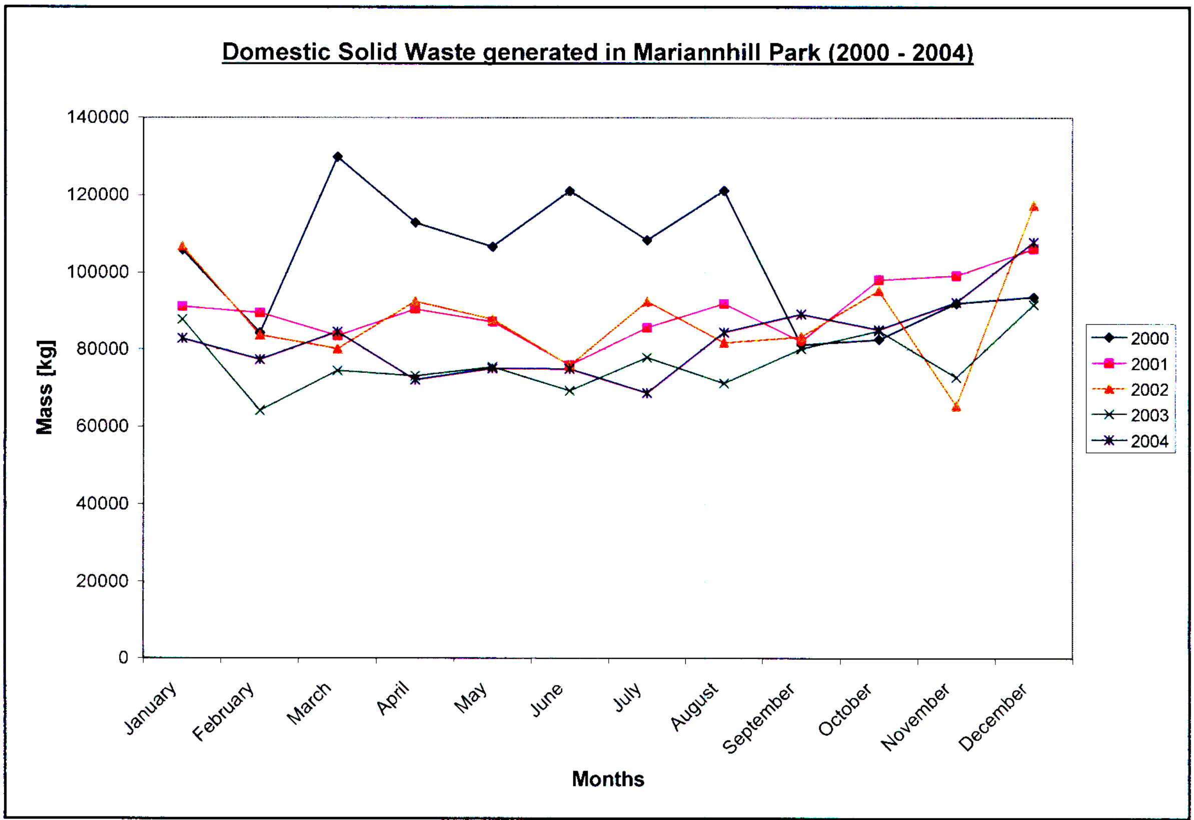

Figure 6.5: Estimated domestic solid waste generated in Mariannhill Park (2000 - 2004)

Table 6.2: Analysis of Variance table for comparison of yearly means for Mariannhill Park

Source	Sum of Squares	Degree of Freedom	Mean Square	F Statistic
Waste Mass	4.4822E+09	4	1.1206E+09	**0.146**
Error	4.2193E+11	55	7.6714E+09	
Total	4.2641E+11	59		
$F_{(4,55;0.05)} = 2.40$				
Since F = 0.146 < 2.40, accept Ho at the 95% Level of Significance.				
There is no reason to believe that the yearly means are unequal.				

Table 6.3: Analysis of Variance table for comparison of seasonal means for Mariannhill Park

Source	Sum of Squares	Degree of Freedom	Mean Square	F Statistic
Waste Mass	3.6653E+09	3	1.2218E+09	0.804
Error	8.5063E+10	56	1.5190E+09	
Total	8.8728E+10	59		
$F_{(3,56;0.05)} = 2.79$				
Since F = 0.804 < 2.79, accept Ho at the 95% level of significance.				
There is no reason to believe that the seasonal means are unequal.				

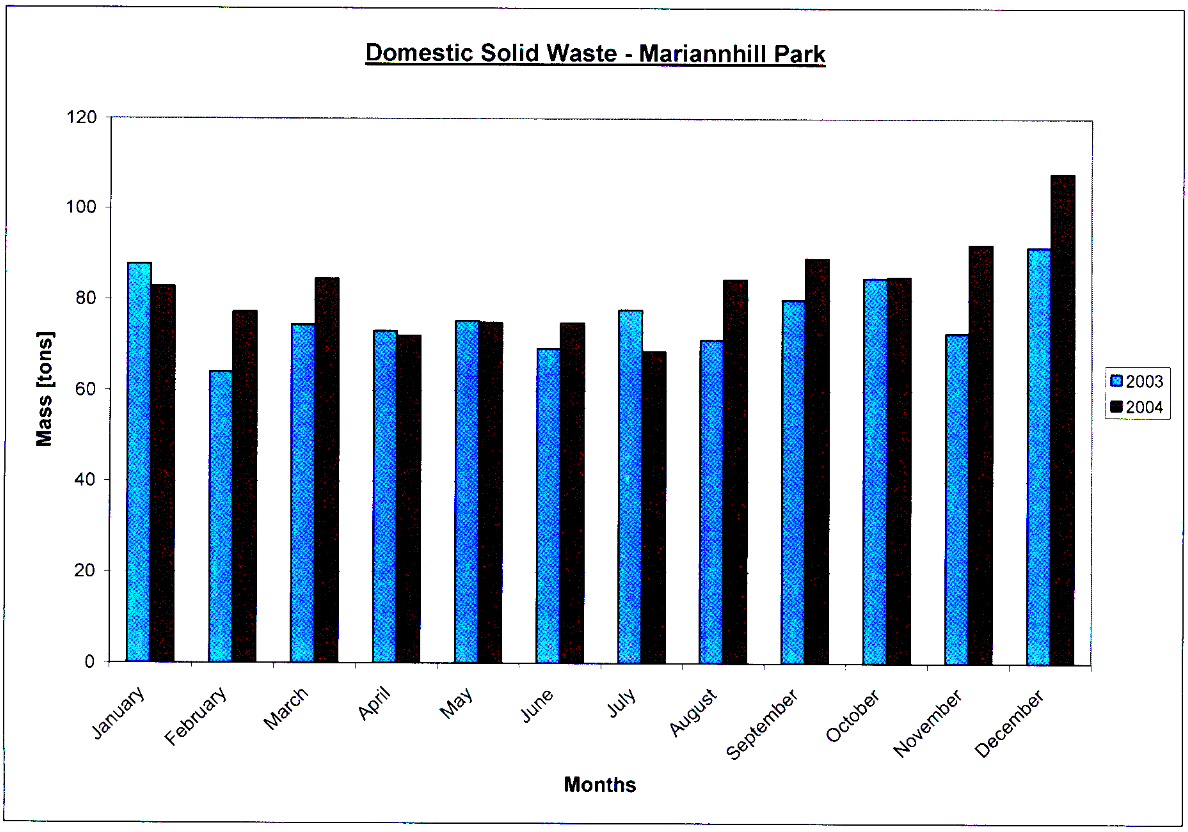

Figure 6.6: Domestic solid waste generated in Mariannhill Park (2003 & 2004)

6.4.1.2 Nazareth

The waste data for Nazareth is shown in Table 6.4 for a five year period (2000 - 2004). It can be seen from the table that the total waste produced in 2002 is the highest of the years analysed, but shows the second least variability within the monthly totals. The lowest total is for 2001, which has a co-efficient of variation of 0.23, the second highest in the data set. This shows that there is no marked difference between any of the years according to this data as depicted in Figure 6.7.

there is no significant difference, at a 95% level of confidence, in the yearly and seasonal means between the five years analysed. But, waste generation data for 2003 and 2004, the years used in the analysis of the proposed ZWS, shows some variability within the monthly totals, while there is a very slight change in total waste generated between 2003 and 2004 as depicted in Figure 6.8. Consequently, average waste generation rate remained constant at about 17.0 kg/household/month.

Table 6.5: Analysis of Variance table for comparison of yearly means for Nazareth

Source	Sum of Squares	Degree of Freedom	Mean Square	F Statistic
Waste Mass	1.0912E+08	4	2.7281E+07	1.450
Error	1.0351E+09	55	1.8820E+07	
Total	1.1442E+09	59		
$F_{(4,55;0.05)} = 2.40$				
Since F = 1.45 < 2.40, accept Ho at the 95% level of significance.				
There is no reason to believe that the yearly means are unequal.				

Table 6.6: Analysis of Variance table for comparison of seasonal means for Nazareth

Source	Sum of Squares	Degree of Freedom	Mean Square	F Statistic
Waste Mass	8.944E+07	3	2.9815E+07	1.583
Error	1.055E+09	56	1.8835E+07	
Total	1.144E+09	59		
$F_{(3,56;0.05)} = 2.79$				
Since F = 1.58 < 2.79, accept Ho at the 5% level of significance.				
There is no reason to believe that the seasonal means are unequal.				

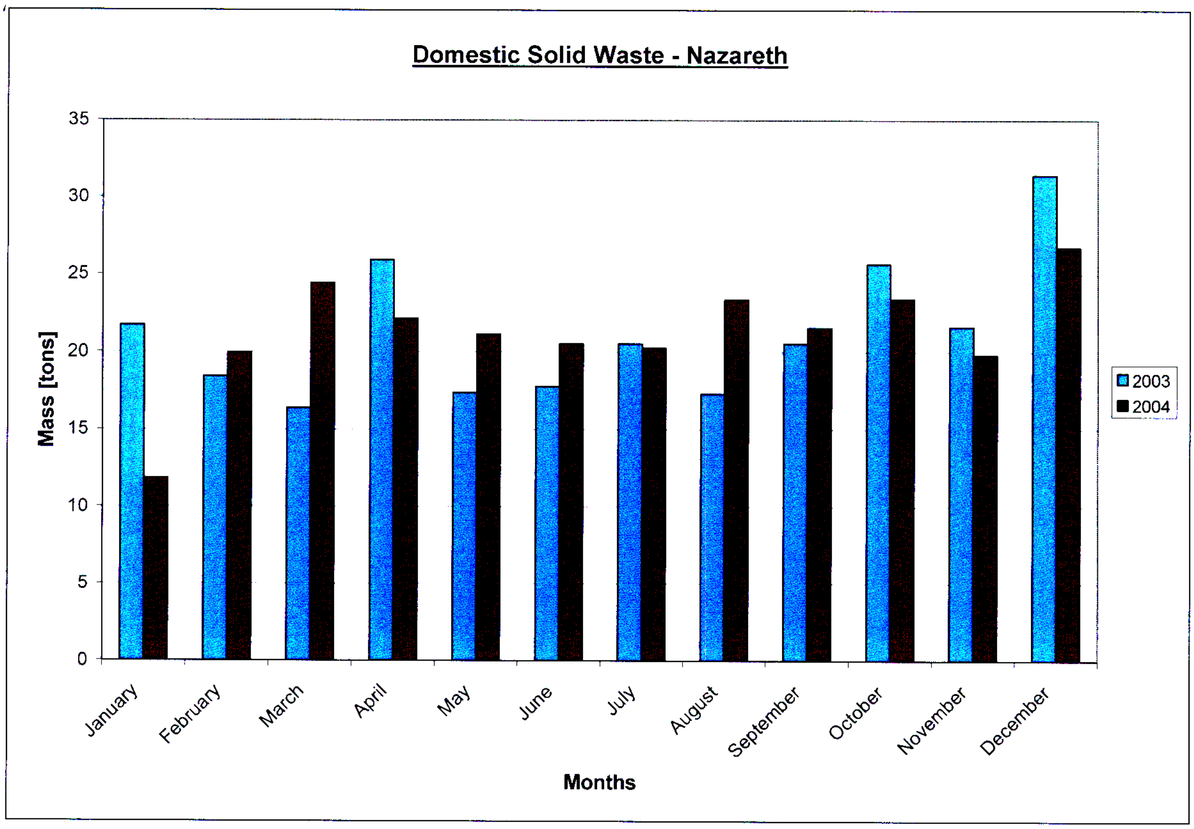

Figure 6.8: Domestic solid waste generated in Nazareth (2003 & 2004)

6.4.2 Recyclables quantities

As discussed in the preceding sections, the environmental analysis of the ZWS used only waste data for 2003 and 2004. The results for Mariannhill Park are discussed in Section 6.4.2.1, while those for Nazareth will be discussed in Section 6.4.2.2.

6.4.2.1 Mariannhill Park

The recyclable fractions in the solid domestic waste for Mariannhill Park were determined using the waste stream data for Durban North as discussed in Section 4.4.2.3. A comparison of the socio-economic, basic services and household type data shows that the areas are comparable, hence it is reasonable to assume that the waste stream data for Mariannhill Park would be similar to that for Durban North. The waste stream composition for recyclables in Durban North is presented in Table 6.8 and was used in calculating the recyclables yield for scenarios 1 a), 1 b) and 2 (see Table 4.1). The waste stream composition for calculating the recyclables yield for scenario 3 is given in Table 6.9. A comparison of the two tables shows that not only is the total fraction of recyclables lower in Table 6.9 than in Table 6.8, the relative fractions of the recyclable materials are different.

The results of the yield of recyclables for 2003 and 2004 for all scenarios, using the waste stream data shown in both tables, are presented in Figure 6.9 and 6.10 respectively. The detailed calculations are attached in Appendix B.2.1.

Table 6.7: Comparison of socio-economic and basic services data Mariannhill Park and Durban North (Source: http:/capmon.durban.gov.za)

		Mariannhill Park	**Durban North**
Population Type	White (%)	67	82
Employment Status	Employed (%)	47	48
	Unemployed (%)	5	2
	Dependency Ratio	2	2
		Number of Households (%)	
Household Income (per annum)	No income	4	2
	R1 – R4800	1	2
	R4801 – R9600	3	6
	R9601 – R19200	4	6
	R19201 – R38400	9	8
	R38400 – R76000	19	12
	R76001 – R153600	32	20
	R153600 – R307200	22	26
Basic Household Services	Electricity	98	99
	Refuse Disposal	100	100
Household Type	Formal	97	98
	Informal	1	1

Table 6.8: Waste stream composition for Durban North (Source: SKC, 2002b)

Recyclable	**Percentage (by Mass)**
Hard plastics (f_{hp})	7
Soft plastics (f_{sp})	17
Glass (f_g)	8
Cans (f_c)	7
Cardboard (f_{card})	5
Other Paper (f_p)	9
Total (f_T)	**53**

Table 6.9: Waste stream composition for Scenario 3 (Source: Douglas, 2007)

Recyclable	**Percentage (by Mass)**
Hard plastics (f_{Mhp})	1.6
Soft plastics (f_{Msp})	4.5
Glass (f_{Mg})	2.3
Cans (f_{Mc})	0.8
Cardboard (f_{Mcard})	9.7
Other Paper (f_{Mp})	4.9
Total (f_M)	**23.8**

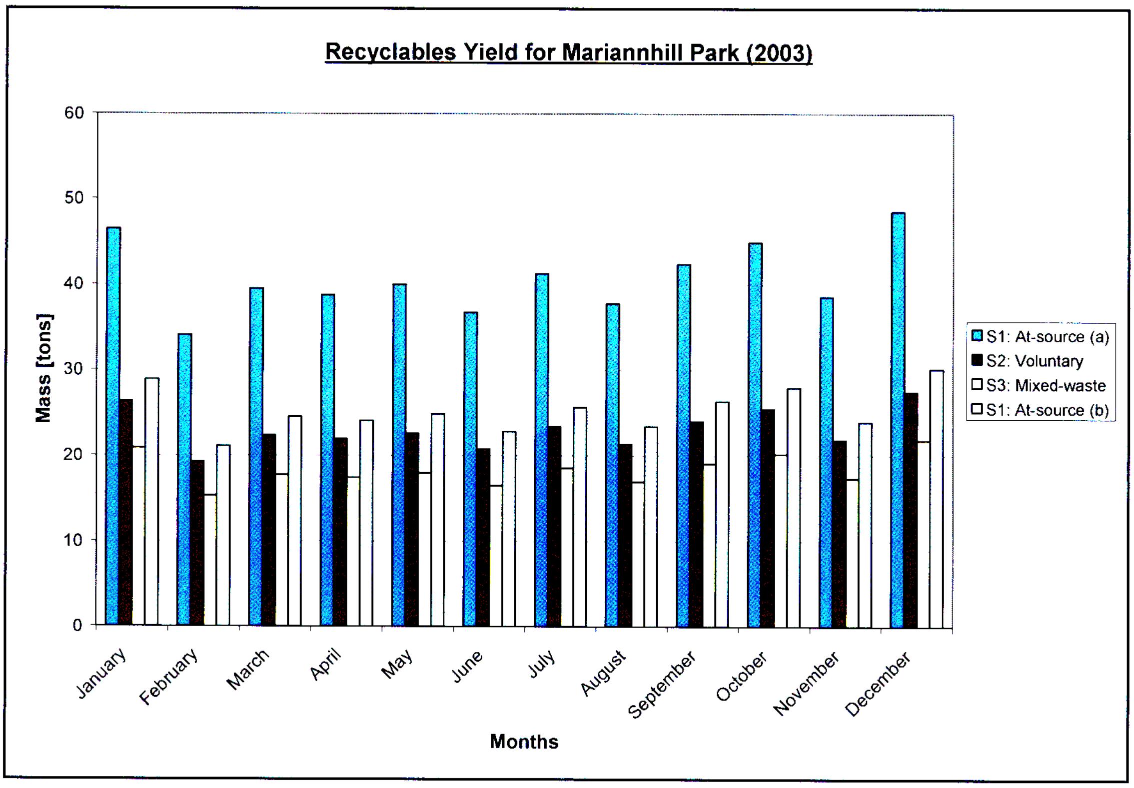

Figure 6.9: Recyclables yield for Mariannhill Park (2003) – All Scenarios

From Figure 6.9, it can be seen that scenario 1a) produces the highest yield of recyclables, with a monthly minimum of 34 tons. This minimum yield is higher than the maximum yield produced by scenarios 1b), 2 and 3, which is as expected give that scenario 2 has a 30% yield of the total household waste generated, and scenario 3 has a yield of about 23% of the total waste generated by households. These differences can be accounted for by the way the scenarios have been set-up.

As explained in Section 4.4.2.3, scenario 1a) represents an operational ideal for at-source separation: full capture of all recyclables and maximum participation by households, with all households in the case study area taking part in the recycling scheme. Realistically though, at-source separation is expected to yield recyclables as seen in scenario 1b) in Figure 6.9, where the yield is consistently higher than both scenarios 2 and 3, but much less than in scenario 1 a). This is due to the fact that 74% of households in Mariannhill Park are willing to source separate their waste and their capture rate for the recyclables will be around 84%. These results were obtained in the social assessment of the proposed ZWS and will be discussed in detail in Section 6.5.2.1. The household participation and capture rates used for 2003 were also used for 2004. The results for 2004 are as depicted in Figure 6.10.

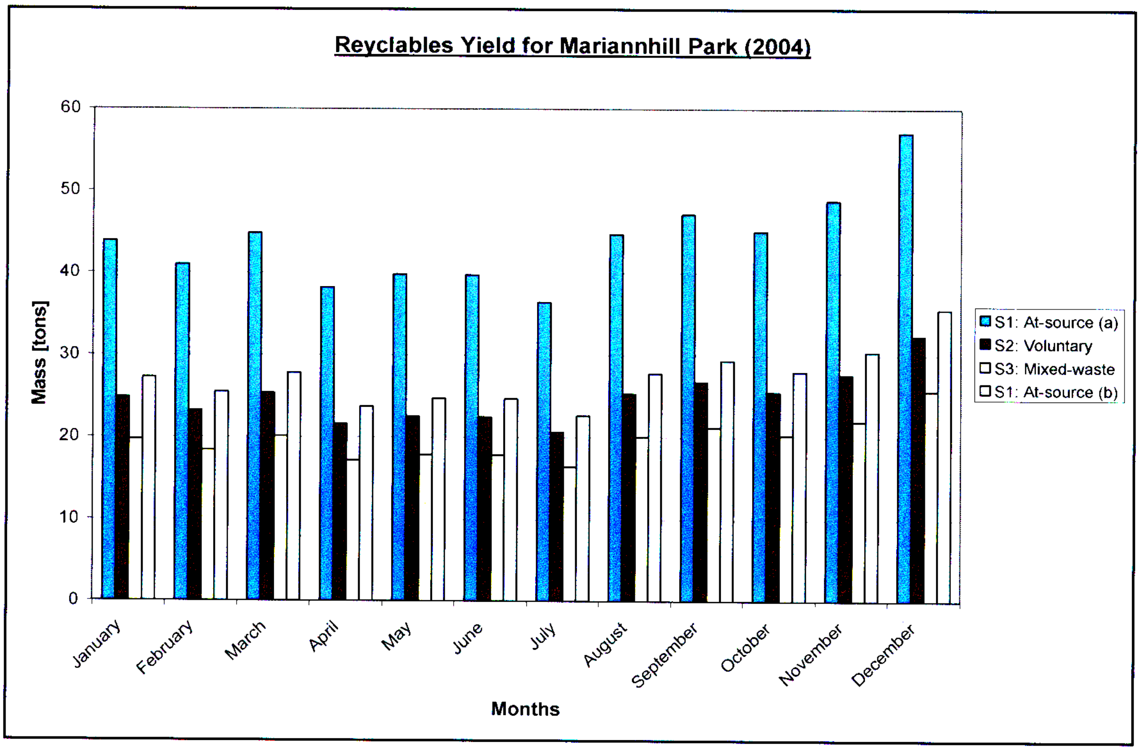

Figure 6.10: Recyclables yield for Mariannhill Park (2004) – All Scenarios

In terms of the recyclables yield for scenarios 1b), 2 and 3, it can be seen from Figure 6.9 that 21 – 30 tons, 19 – 27 tons and 15 – 22 tons are generated per month respectively. Due to an increase in waste generation between 2003 and 2004, 23 – 36 tons, 21 – 32 tons and 16 – 26 tons are generated per month respectively for each scenario as seen in Figure 6.10. Hence, over the two years of analysis, Mariannhill Park is expected to yield a minimum of 21 tons/month of recyclables with at-source separation by households which will increase year on year.

6.4.2.2 Nazareth

The recyclable fractions in the solid domestic waste for Nazareth were determined using the waste stream data for Umlazi as discussed in Section 4.4.2.3. A comparison of the socio-economic, basic services and household type data shows that the areas are comparable, hence it is reasonable to assume that the waste stream data for Nazareth would be similar to that for Umlazi. The waste stream composition for recyclables in Umlazi is presented in Table 6.11. This is the waste composition used in calculating the recyclables yield for scenarios 1 a), 1 b) and 2 (See Table 4.1). The waste stream composition for calculating the recyclables yield for scenario 3 is as given in Table 6.9. A comparison of Tables 6.8 and 6.11 shows that the total fraction of recyclables is lower in Table 6.8 than in Table 6.11 and the relative fractions of the recyclable materials are different. The results of the yield of recyclables for 2003 and 2004 for all scenarios, using the waste stream data shown in Table 6.9 and 6.11, are presented in Figure 6.11 and 6.12 respectively. The detailed calculations are attached in Appendix B.2.2.

From Figure 6.11, it can be seen that scenario 1a) produces the highest yield of recyclables, with a monthly minimum of 11 tons. This minimum yield is higher than the maximum yield produced by scenarios 1b), 2 and 3, which is as expected give that scenario 2 has a 30% yield of the total household waste generated, and scenario 3 has a yield of about 23% of the total waste generated by households. These differences can be accounted for by the way the scenarios have been set-up. Also, the overall yields depicted in Figure 6.11 are lower than those for Mariannhill Park given the lower waste generation rates for Nazareth.

Table 6.10: Comparison of socio-economic and basic services data Nazareth and Umlazi (Source: http:/capmon.durban.gov.za)

		Nazareth	Umlazi
Population Type	Black (%)	82	100
Employment Status	Employed (%)	30	18
	Unemployed (%)	14	27
	Dependency Ratio	3	6
		Number of Households (%)	
Household Income (per annum)	No income	19	28
	R1 – R4800	5	7
	R4801 – R9600	12	15
	R9601 – R19200	16	16
	R19201 – R38400	17	18
	R38400 – R76000	12	11
	R76001 – R153600	10	4
Basic Household Services	Electricity	82	79
	Refuse Disposal	94	98
Household Type	Formal	88	71
	Informal	5	22

Table 6.11: Waste stream composition for Umlazi (Source: SKC, 2002b)

Recyclable	Percentage (by Mass)
Hard plastics (f_{hp})	6
Soft plastics (f_{sp})	25
Glass (f_g)	7
Cans (f_c)	6
Cardboard (f_{card})	12
Other Paper (f_p)	13
Total (f_T)	**69**

As explained in Section 4.4.2.3, scenario 1a) represents an operational ideal for at-source separation: full capture of all recyclables and maximum participation by households, with all households in the area taking part in the recycling scheme. Realistically though, at-source separation is expected to yield recyclables as seen in scenario 1b) in Figure 6.11, where the yield is consistently higher than both scenarios 2 and 3, but much less than in scenario 1a). This is due to the fact that 73% of households in Nazareth are wiling to source separate their waste and their capture rate for the recyclables will be around 85%. These results were obtained in the social assessment of the proposed ZWS and will be discussed in detail in Section 6.5.2.2. The household participation and capture rates used for 2003 were also used for 2004. The results for 2004 are as depicted in Figure 6.12.

In terms of the recyclables yield for scenarios 1b), 2 and 3, it can be seen from Figure 6.11 that 7 – 13 tons, 5 – 9 tons and 4 – 7 tons are generated per month respectively. Although there is a very slight increase in waste generation between 2003 and 2004, the recyclables yield for 2004 is different due to changes in monthly generation rates. This means that 5 – 11 tons, 4 – 8 tons and 3 – 6 tons are generated per month respectively for scenarios 1b), 2 and 3 as seen in Figure 6.12. Hence, over the two years of analysis, Nazareth is expected to yield a minimum of 4 tons/month of recyclables with at-source separation by households. This yield will fluctuate monthly from 2003 to 2004, but with no noticeable increase in overall levels between the two years.

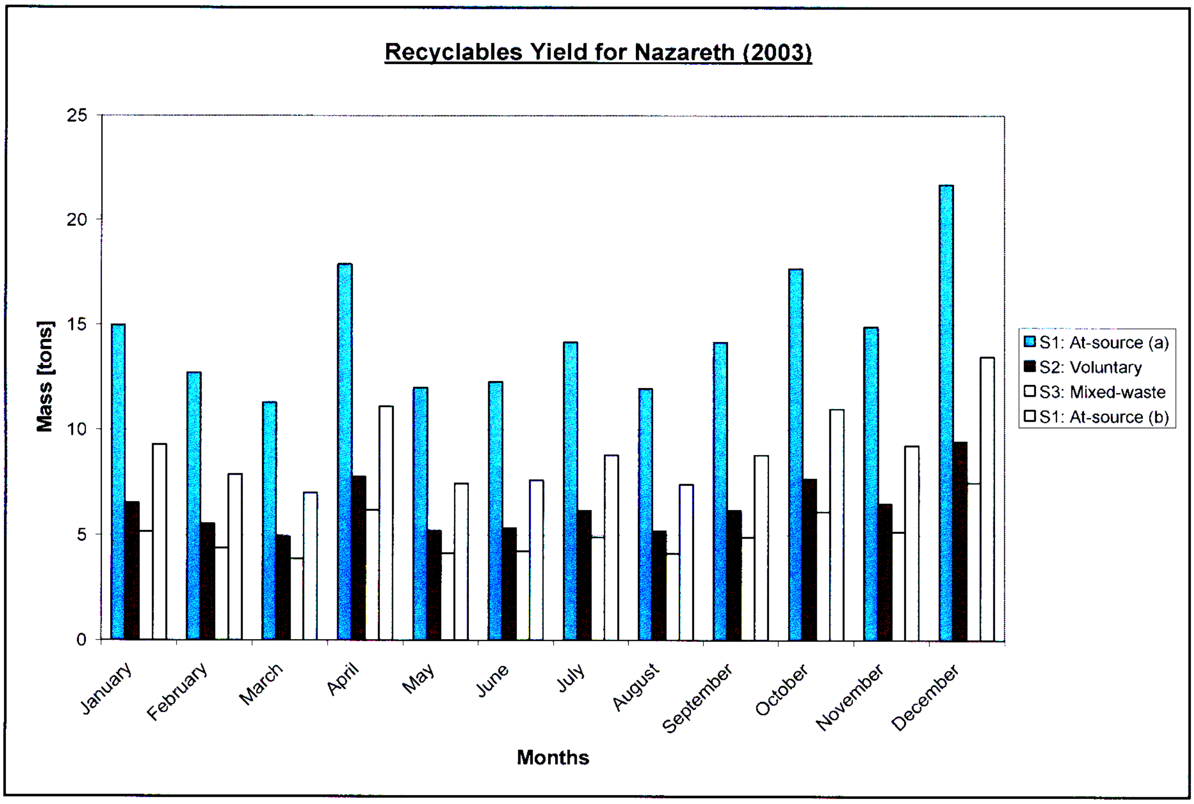

Figure 6.11: Recyclables yield for Nazareth (2003) – All Scenarios

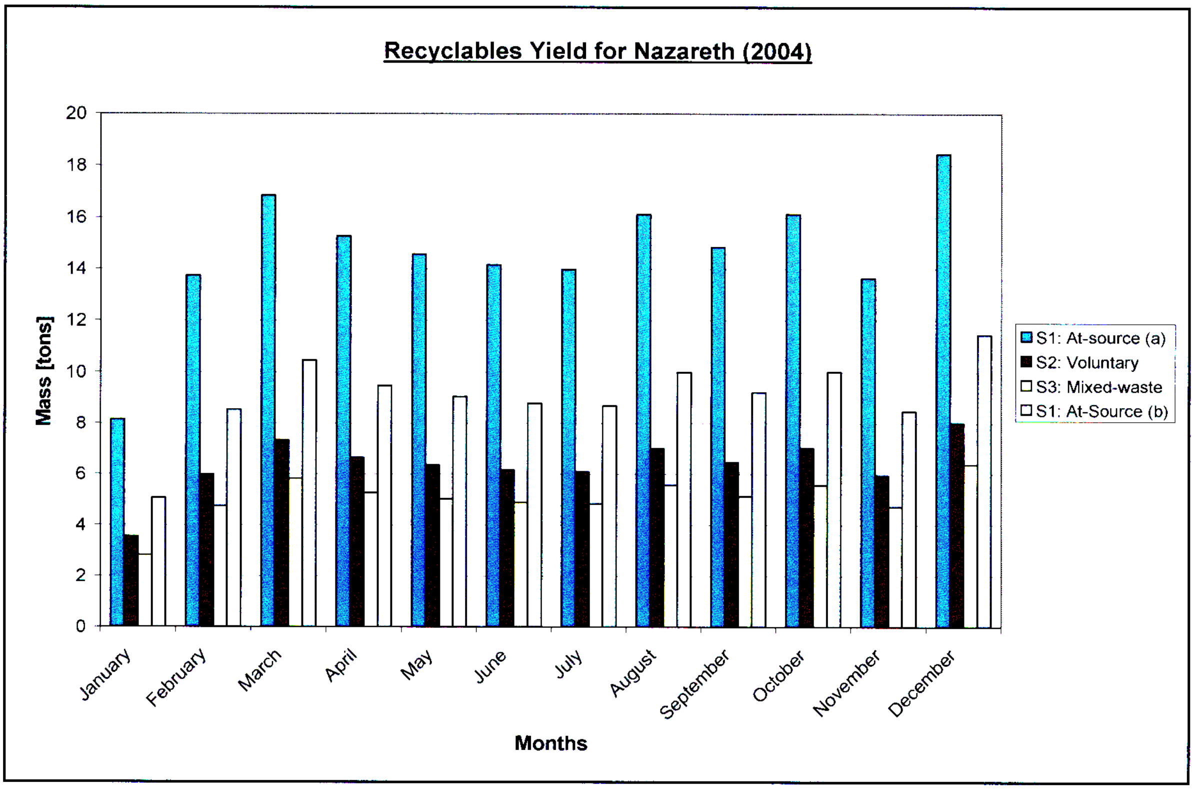

Figure 6.12: Recyclables yield for Nazareth (2004) – All Scenarios

6.4.3 Landfill space saving

The amount of landfill space that could be saved from the application of the ZWS is the most important result of the environmental assessment. The results for landfill space saving (LSS) that could be achieved with the proposed ZWS will be discussed in this section. The assessment results for each case study area will be presented separately. Section 6.4.3.1 is a presentation of the results for Mariannhill Park, while Section 6.4.3.2 is a presentation of the results for Nazareth.

6.4.3.1 Mariannhill Park

The results of LSS, in terms of conserved landfill volumes due to the application of the ZWS for Mariannhill Park are shown in Figure 6.13 and 6.14 for 2003 and 2004 respectively.

Figure 6.13 summarises the landfill space utilization that would occur as a result of the application of the four scenarios that have been analysed. These have been compared to the base case scenario: landfill space utilisation when no recycling has been applied at Mariannhill Park. It can be seen from Figure 6.13 that the disposal of residual waste arsing from scenario 1a) utilises 47% of the landfill space. This means that if all the recyclables, based on waste stream data in Table 6.7, generated by all households in Mariannhill Park could be source separated, all other things being equal, then the life-span of the landfill could be doubled. This increase in landfill span would be less pronounced in the other scenarios, with scenarios 1b), 2 and 3 extending the life-span of the landfill by a factor of 1.5, 1.4 and 1.3 respectively. These figures would apply equally to the 2004 LSS as depicted in Figure 6.14. The increase in landfill life-span is significant given the problems associated with siting new landfill sites and increased transport costs as discussed in Section 1.1.

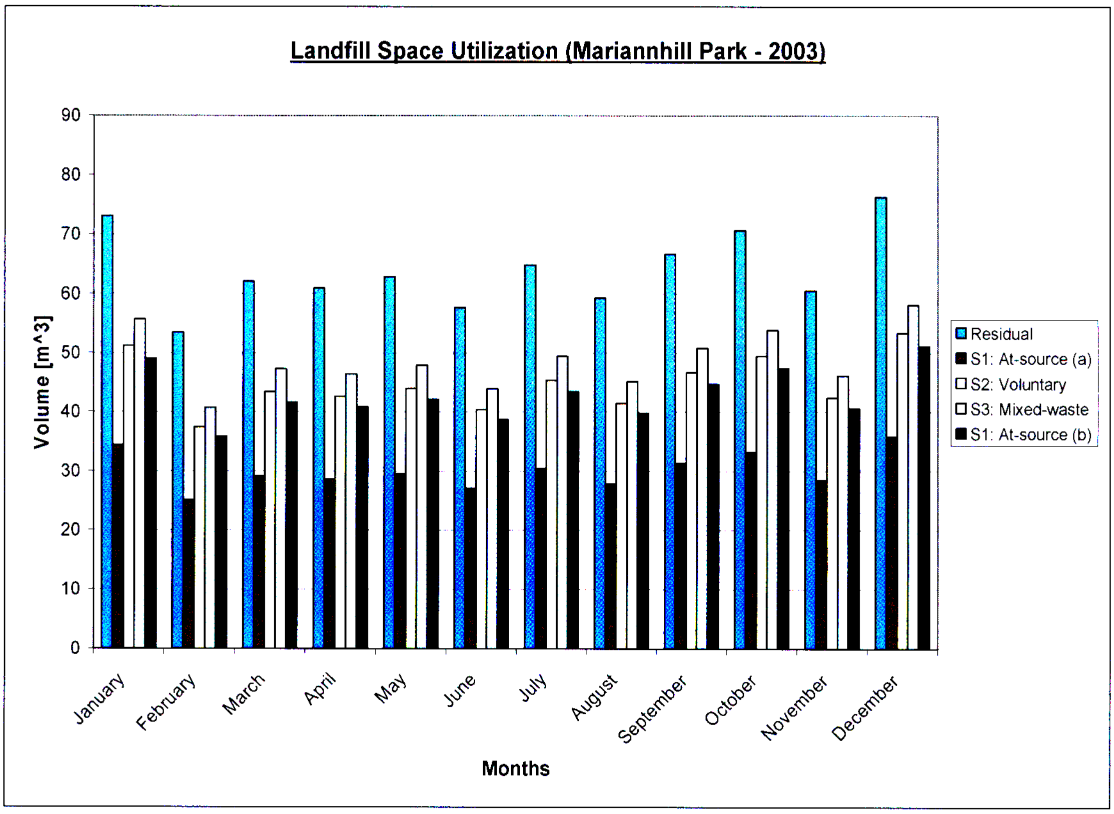

Figure 6.13: Landfill Space Utilisation for Mariannhill Park (2003)

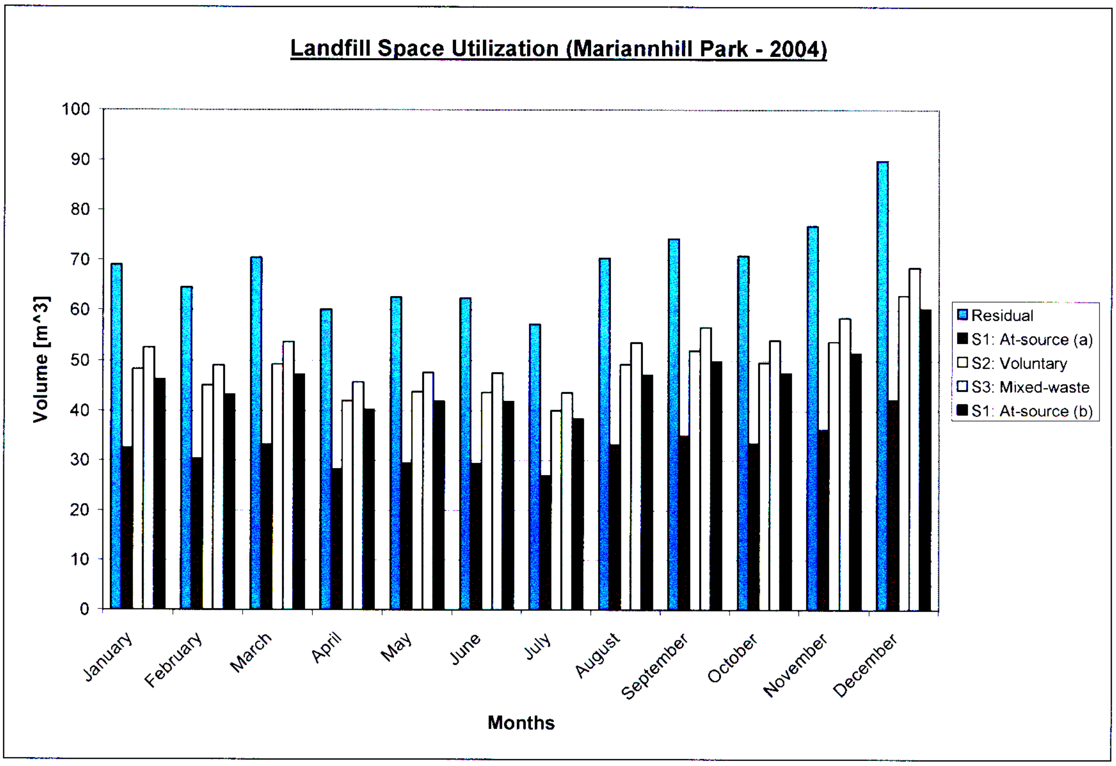

Figure 6.14: Landfill Space 19Utilisation for Mariannhill Park (2004)

In terms of actual volumes, Figure 6.13 shows that scenario 1a) saves $34m^3$/month of landfill space on average, while scenarios 1b), 2 and 3 save $21m^3$/month, $19m^3$/month and $15m^3$/month respectively. This means that while $34m^3$/month can be saved ideally with at-source separation of recyclables, $21m^3$/month can be saved realistically. These volumes would increase to $37m^3$/month and $23m^3$/month respectively for 2004 as depicted in Figure 6.14. In conclusion, the preceding LSS figures are what would be possible with application of a recycling scheme at Mariannhill Park, whether it be with at-source separation, voluntary recycling or mixed-waste recycling. But according to these figures, recycling with at-source separation would be much more environmentally beneficial than the latter two methods.

6.4.3.2 Nazareth

The results of LSS, in terms of conserved landfill volumes due to the application of the ZWS for Nazareth are shown in Figure 6.15 and 6.16 for 2003 and 2004 respectively.

Figure 6.15 summarises the Landfill space utilization that would occur as a result of the application of the four scenarios that have been analysed. These have been compared to the base case scenario. It can be seen from Figure 6.15 that the disposal of residual waste arsing from scenario 1a) utilises 31% of the landfill space. This means that if all the recyclables, based on waste stream data in Table 6.7, generated by all households in Mariannhill Park could be source separated, all other things being equal, then the life-span of the landfill could be more than tripled. This increase in landfill span would be less pronounced in the other scenarios, with scenarios 1b), 2 and 3 extending the life-span of the landfill by a factor of 1.7, 1.4 and 1.3 respectively. These figures would apply equally to the 2004 LSS as depicted in Figure 6.14. The significance of the increase in life-span has already been already established in Section 6.3.4.1.

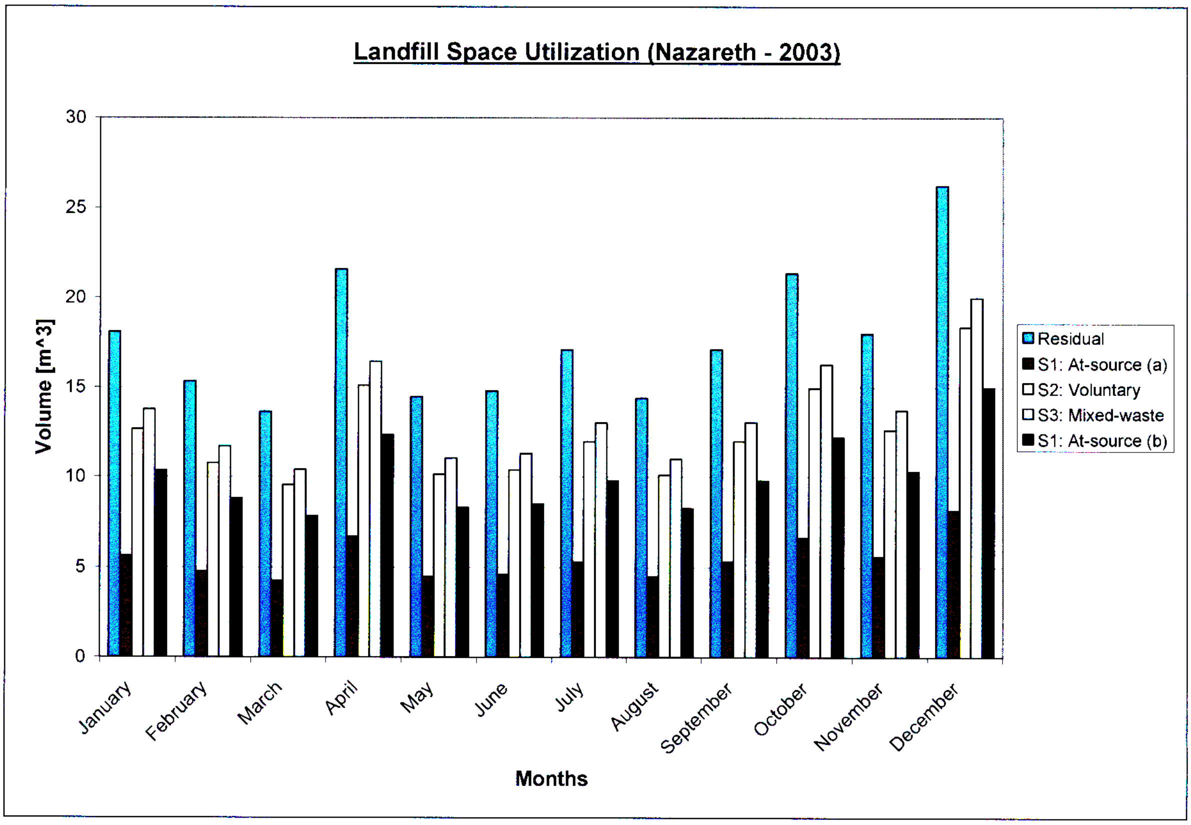

Figure 6.15: Landfill Space Utilisation for Nazareth (2003)

In terms of actual volumes, Figure 6.15 shows that scenario 1a) saves 12m^3/month of landfill space on average, while scenarios 1b), 2 and 3 save 8m^3/month, 5m^3/month and 4m^3/month respectively. This means that while 12m^3/month can be saved ideally with at-source separation of recyclables, 8m^3/month can be saved realistically. These volumes would be the similar for 2004 as depicted in Figure 6.16. In conclusion, the preceding LSS figures are what would be possible with application of a recycling scheme at Nazareth, whether it be with at-source separation, voluntary recycling or mixed-waste recycling. But according to these figures, recycling with at-source separation would much more environmentally beneficial than the latter two methods.

6.4.4 End-life cycle assessment

The outcomes of the ELCA for the recyclables will be discussed in this section. The aim of this section is to show that markets for the recyclables that would be generated in Mariannhill Park and Nazareth would be available. Whether the markets for the recyclables are viable or not will be discussed in the economic assessment in Section 6.6.

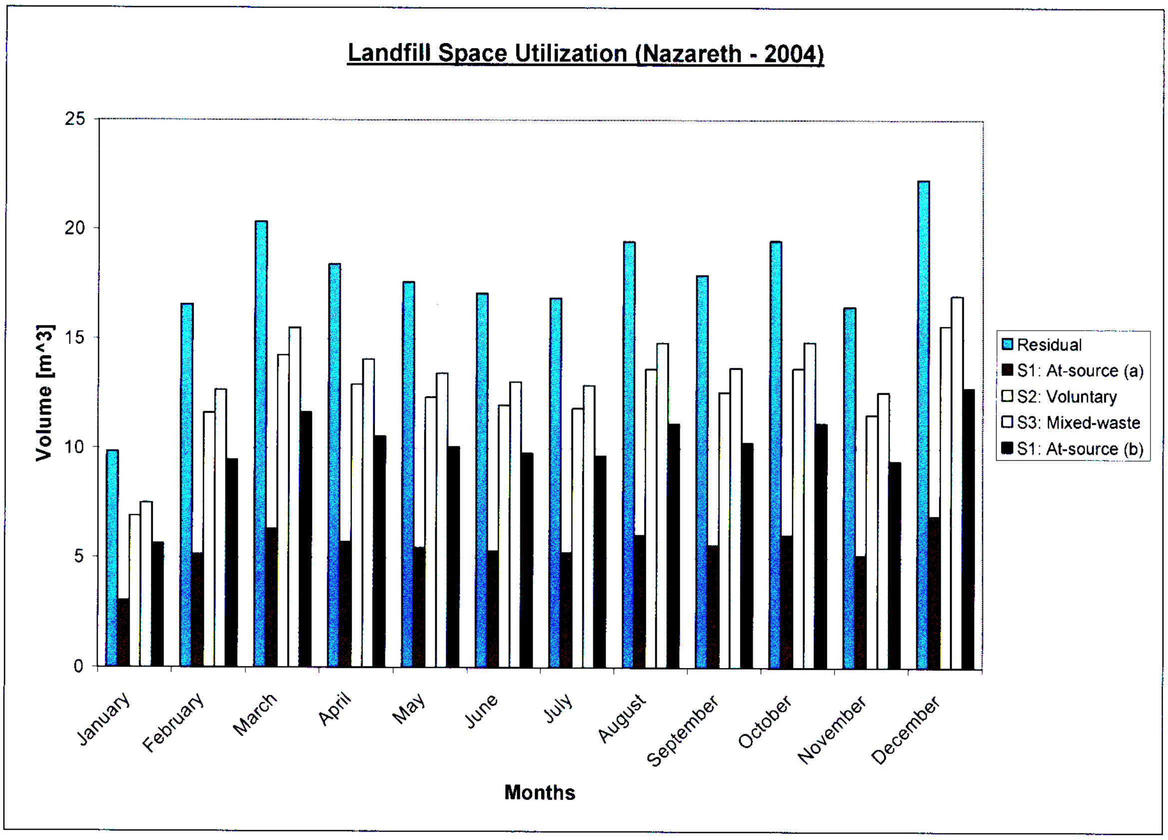

Figure 6.16: Landfill Space Utilisation for Nazareth (2004)

6.4.4.1 Westmead Recycling Centre

The Westmead Recycling Centre is a buyback centre located in Westmead, approximately 4 km and 6 km from Mariannhill Park and Nazareth respectively. The Centre was set up with the financial help of the waste minimisation and recycling division (DSW) and is operated by an owner/manager under the supervision of DSW.

The centre collects recyclables from the Westmead Industrial area and surrounding areas in Pinetown. The extent of the collection area is variable and not quantifiable at present. Hence, the impact of the collection of the recyclables on the waste stream for both Mariannhill Park and Nazareth, should households want to drop-off their recyclables at the centre, cannot be readily assessed. Recyclables are brought to the centre by collectors in the area. Separation/sorting is carried out on site, with of some of the recyclables (PET and HDPE bottles) being baled. The centre has seven labourers employed full time, with casual labour employed as the need arises. Collectors are paid for the recyclables they deliver, with the prices paid out being dependent on the prevailing buying prices set by the converters, that is, companies that buy recyclables and process them into consumer products. The materials collected at the centre include mild steel, mild steel (sub-grade), aluminium, copper, brass, stainless steel, cardboard, paper and plastic. The collected recyclables are then stored in skips awaiting collection by the various companies. Once a skip is full, the manager notifies the relevant company; the company collects the skip and leaves an empty skip at the centre. Table 6.12 shows the spot buying prices for the aforementioned recyclables. These spot prices are the prices paid to collectors bringing recyclables to the centre on 15 March 2005. The selling price is set by converters and includes collection of recyclables from the centre (Ngcobo, 2005).

Table 6.12: Spot buying prices at Westmead Recycling centre (Source: Ngcobo, 2005)

Material	**Price [R/kg]**	
	Normal grade	**Sub-grade**
Cardboard	0.15	
Paper	0.40	0.25
Copper	7.00	5.50
Brass	5.00	2.50
Mild Steel	0.15	0.15
Stainless Steel	0.40	
Aluminium	5.00	1.50
Plastic (Wrap)	0.05	
Plastic (PET)	0.20	
Plastic (Colour)	0.70	
Plastic (Milk)	0.20	
Glass	0.05	

The following is a list of converters (1 – 4) and buyers (5 – 6) collecting recyclables from the centre:

1. Reclamation Group – ferrous and non-ferrous metals
2. Nampak Recycling – paper
3. Mondi Recycling – paper and cardboard
4. Collect-a-can – used beverage cans and other types of cans
5. Sunset Scrap Metals – mild steel

6. DC Plastics, Wolf brothers, MCFI International and Jake Recyclers – all types of plastics

6.4.4.2 End-life cycle assessment for recyclables

The ELCA for cans, paper, plastic and glass will be discussed in this section. It is important to note that while interviews were carried out with representatives of recycling companies for cans and paper, similar interviews for plastics and glass could not be obtained. As a result, websites for plastics and glass, as well as other publications, were consulted in the ELCA for plastics and glass.

Cans

Main company/collector/converter is Collect-a-Can located in Westmead (Pinetown). Collect-a-Can is a non-governmental Organisation (NGO) funded by Iscor (Mittal) and Nampak. Although Iscor and Nampak hold a stake in the company, the company is self-financing. The buying price for the recycled cans is set by the Collect-a-Can head office in Johannesburg and is influenced by the prevailing steel prices.

The Westmead centre is the main depot for KwaZulu-Natal and the Eastern Cape, with satellite depots in Pietermaritzburg, East London, Richard's Bay and Umtata. Cans collected at the satellite depots are weighed and baled before being transported to the main depot in Westmead. The centre sources cans from small businesses, individuals, schools, charities, and church groups and at sports events. In-house contractors collect the cans from the various sources and transport them to the centre, where the cans are sorted, weighed and baled, ready for transportation to the mills. The cans are sorted on-site into various categories, which include beverage (aluminium and steel), food, paint, aerosol and oilcans. Aluminium cans fetch the highest price, followed by steel and then the other categories (Ngcobo, 2005).

Baled cans are sent to a de-tinning plant in Vanderbijlpark where the tin component is stripped from the cans. The plant has two processing lines, one for baled cans and the other for loose cans. On a single-shift basis the lines process about 1500 tons/month and 250 tons/month of feed respectively. As a result, 36000 tons of steel are recovered each year for re-melting and processing into various steel products, which include beverage cans.

Paper

Main companies/collectors/converters are Mondi Recycling and Nampak Recycling. The converter investigated in this case was Mondi Recycling. The main Mondi recycling depot is located on Maydon wharf. All the paper and cardboard collected in the Durban area is sent to this depot. Collection takes place through commercial pick-up services, the schools pick-up programme and community pick-up service. The community paper pick-up service includes paper banks at convenient locations (for example, shopping centres), kerbside pick-up in selected communities, small business pick-up service, buy back centres and paper collection barrows provided to hawkers.

Collection of the waste paper is carried out by contracted owner/drivers from the areas concerned (Botha, 2005; Mondi, 2005). It is then transported to the depot where it is sorted into the different types and various grades, then baled, ready for transportation to the mills. Merebank Mill in KwaZulu-Natal produces Rotatrim paper, newspaper and magazine paper with 3% recycled fibre content (Botha, 2005). Springs Mill in Johannesburg reprocesses white paper. Piet Retief Mill in Mpumalanga deals mainly with the processing of cardboard (Botha, 2005). Felixton Mill in Richard's Bay also processes cardboard. The processing capacities of the aforementioned mills are kept confidential (Botha, 2005).

According to Mondi Recycling Newsletter (undated), only a few products are made entirely from recycled paper. These are: egg boxes and trays; wine bottle sleeves and; some brands of tissue paper and kitchen rolls. However, many other products are made from recycled paper mixed with fresh pulp. The recycled content of these recycled products is not known at present. These products are: paper tissue, towels and toilet paper; brown wrapping paper; cardboard and cardboard cores inside rolls of tissue paper, kitchen towels, foil; backing boards for writing and drawing pads; inner stiffeners of plastic covered ring binders; tissue paper used to protect fresh fruit and; newsprint.

For processing purposes, fresh wood pulp has to be added to recycled fibre because the recycled fibre is not as strong as fresh pulp. If the fibre was to be recycled over and over, after about six to eight times the fibre would become too weak to bond together in the new sheet of paper (Mondi Recycling Newsletter, undated).

Plastics

According to Beningfield (2002), with more than 60 types of plastic resins that exist, there are seven that are most common. These are PET (polyethylene terephthalate), HDPE (high-density polyethylene), PVC (polyvinyl chloride), LPDE (low-density polyethylene), PP (polypropylene), PS (polystyrene) and laminates (Beningfield, 2002). Given the large number of resins, it is easier to mechanically recycle industrial post-consumer plastics rather than domestic household plastics (Plastics Federation of South Africa, 2007). This is due to the fact that industrial processes produce large amounts of single plastic types as compared with households which produce a large number of plastic types (PFSA, 2007). Similarly industrial waste plastic is much cleaner that household plastic waste (PFSA, 2007).

Collection of plastics using single household points is not feasible due to plastic being lightweight, hence drop-off points called green cages have been located conveniently for collection of plastic recyclables arising from households (PFSA, 2007). Given the large number of resins, there are seven such sites in the greater Durban area, with the majority being located at garden refuse sites, from where the plastic is collected by one-person businesses for sorting and grading (PFSA, 2007). The labour costs are estimated at R70/ton, while transportation costs are estimated at R750/ton for transportation within a 50km radius (Beningfield, 2002). The collected plastics are sorted by type, baled at a 6:1 compression ratio and delivered to converters who may do further sorting once the bales have been delivered (PFSA, 2007). There are currently over 123 converters in South Africa (Beningfield, 2002), with at least one in KwaZulu-Natal that processes approximately 300 tons of waste plastic per year (Nampak, 2007).

The collected plastics can be converted into the following materials (PFSA, 2007):

a) LDPE and PP can be recycled back into film and garbage bags; bumper bars and case from car batteries can be recycled into water tanks and compost bins.
b) PET bottles are either used to make bottles with 25% recycled content or exported to be used in carpets, ecofleece (clothing) and other synthetic fibre applications.
c) HDPE, one of the main plastics collected and sort after in the recycling chain, is used mainly to produce the large plastic wheelie bin
d) Recycled plastic is also used to make outdoor furniture, guide posts, building panels, railway sleepers, vine poles and chemical spill trays

It is interesting to note that PET is 100% recyclable (PETCO, 2007) and that in Europe, technology has been developed and approved for PET to be recycled into bottles (Beningfield, 2002). With around 50% of recycled plastic in South Africa being PET (Beningfield, 2002), it is clear that plastics can potentially be reprocessed using close-loop recycling, which means an indefinite life cycle where disposal is not required.

Glass

According to Consol (2007), there are no fusion losses in the melting process when recycling glass, which means that it takes one ton of recycled glass to produce one ton of new glass. This fact is important since it takes approximately 1.2 tons of virgin materials to manufacture one ton of glass (Consol, 2007). However, in order to derive the maximum return from its recycling, the collected glass has to be sorted into its major colours: white, brown and green (Beningfield, 2002). Also contaminants have to be removed before the glass can be reprocessed (Consol, 2007). Without these contaminants, glass is 100% recyclable (Consol, 2007), which means that it has an indefinite life-cycle and thus lends itself to closed-loop recycling.

Similar to plastics, glass is collected at drop-off points, known as bottle banks, which are situated in urban towns in South Africa to assist domestic recoveries (Consol, 2007). In KwaZulu-Natal, large generators, shopping malls for example, usually have their glass collected in skip by collectors (Beningfield, 2002). The glass is then transported to Johannesburg (Beningfield, 2002), where it is sent to one of nine processing plants (Consol, 2007); processing plants are also located in the Western Cape (Beningfield, 2002; Consol, 2007). Labour and collection costs are high, with separation of various grades costing about R70/ton, local transportation about R40/ton and long-distance about R135/ton (Beningfield, 2002). Despite this high costs, the post-consumer market for KwaZulu-Natal has shown great growth, but requires subsidisation to implement a sustainable programme (Beningfield, 2002).

6.5 Social assessment

In this section the results of the questionnaire application in Mariannhill Park and Nazareth will be discussed. As explained in Section 4.5.3, the main purpose of the questionnaire was to assess the willingness of households to source separate their waste and their willingness to recycle the fractions earmarked for the ZWS. Household attitudes towards recycling and their waste minimisation behaviour were also assessed. Initially, the questionnaire was applied only to Mariannhill Park and Nazareth. However the analysis of the questionnaires was inconclusive when assessing willingness to source separate and willingness to recycle based on income. As a result, the survey was modified to add Westville Central in order to assess the effect of income on the aforementioned factors. It is the results of this analysis that are produced in this section.

6.5.1 Questionnaire application

In Mariannhill Park and Nazareth, the questionnaires were administered during weekends so that the maximum number of households, as determined for the study, could be reached. Whilst the questionnaire had been printed in two languages, respondents from Mariannhill answered the both the English and isiZulu questionnaires, while those from Nazareth mostly answered the isiZulu questionnaire. In both cases, respondents were unable to rank the issues listed in Question 8 according to order of importance. As a result, this question had to be left out of the analysis.

As for Westville Central, the interview process was carried out using convenience sampling. The sample was chosen from people utilizing Westville Mall. Before each respondent could fill in the questionnaire, they were asked whether they resided in Westville Central or not. Those who responded in the affirmative were then asked to fill in the questionnaire. The use of a self-administered questionnaire made it possible to capture the calculated sample size within a short period of time.

The sample size for the survey was calculated using Equation 4.9. Using the parameters defined in Section 4.5.3.2, the total sample size was found to be 235 respondents. The sample was then stratified using Equation 4.10 to give the relative proportion of households required in the three communities. The results are given in Table 6.13 along with the number of questionnaires that were completed from the survey for each community.

Table 6.13 shows that the final sample size was more than the calculated, but within that larger actual sample size, the number of respondents from Mariannhill Park was lower than expected. As can be seen, the response rate for Mariannhill Park was very low, while that for the other two areas was almost double the expected. This could be accounted for by the fact that most households in Mariannhill Park have security fencing and it was difficult to gain entry into such households, even though the questionnaire stated that the study was being conducted in collaboration with DSW. This problem of entry did not exist in Nazareth where most households do not have a security fence. The high response rate in Westville Central was due to the use of a convenience sample. This issue of under-representation from Mariannhill Park will need to be taken into account when interpreting the results of the questionnaire analysis.

Table 6.13: Sample size for questionnaire application

Community	Number of Households	Calculated Sample Size	Number of Filled Questionnaires
Mariannhill Park	3000	161	101
Nazareth	1250	67	127
Westville Central	1115	60	119
Total	**4365**	**235**	**347**

6.5.2 Questionnaire analysis

As shown in Table 6.13, the total number of households surveyed was 347. Although the statistics for the demographics for all three communities are presented in Table 6.14 and Table 6.15, in-depth analysis of the questionnaire will be carried out for Mariannhill Park and Nazareth only. The distinction between the two areas and Westville is due to the fact that both areas are the main concern of the study, while Westville Central was included to assess the issue of differences in income level in predicting the behaviours that were assessed.

Table 6.14 shows that females (47%) were under-represented in Mariannhill Park and the younger age group (18 – 35) accounted for most of the respondents in Mariannhill Park and Nazareth, while the older age group (36 and older) accounts for most of the respondents in Westville Central. As expected, most of the respondents were English speaking in Westville Central (80%) and isiZulu speaking in Nazareth (80%), whereas there was roughly a 50/50 split between the two languages in Mariannhill Park. In terms of type dwelling, households formed the majority of the sample in all three areas with levels of occupation spread out amongst the given categories. Finally, most respondents (80% and above) did not belong to any conservation society. This could imply that most of the respondents do not practice waste minimisation and would probably not be willing to engage in recycling given the fact that it is usually members of conservation societies that would engage or would be willing to engage in such behaviour.

Table 6.14: Demographic composition of survey samples

	Mariannhill Park		Nazareth		Westville Central	
	n	%	n	%	n	%
Gender						
Male	58	57	58	46	58	48
Female	43	43	69	54	61	51
Total	101	100	127	100	119	100
Age						
18 – 25	39	38	43	34	31	26
26 – 35	29	29	33	26	21	18
36 – 50	24	24	33	26	36	30
51 – 65	7	7	14	11	24	20
66 & older	2	2	4	3	7	6
Total	101	100	127	100	119	100
Language						
Afrikaans	2	2	1	1	8	7
English	40	40	13	10	96	80
isiZulu	51	50	101	80	9	8
isiXhosa	3	3	8	6	-	-
Other	5	5	4	3	6	5
Total	101	100	127	100	119	100
Dwelling						
House	65	64	76	60	97	81
Semi-detached	4	4	26	20	7	6
Flat	30	30	9	7	13	11
Other	2	2	16	13	2	2
Total	101	100	127	100	119	100
Occupants						
2 or less	25	24	9	7	30	25
3	24	24	21	16	20	17
4	24	24	21	16	38	32
5	15	15	33	27	21	18
6 or more	13	13	43	34	10	8
Total	101	100	127	100	119	100
Conservation						
Yes	7	7	23	18	15	13
No	94	93	104	82	104	87
Total	101	100	127	100	119	100

Table 6.15: Income categories for survey samples

Income (R/month)	Mariannhill Park		Nazareth		Westville Central	
	n	%	n	%	n	%
Less then 400	6	6	43	34	7	6
401 – 3200	22	22	51	40	11	9
3201 – 12800	37	36	24	19	42	35
12801 – 52100	24	24	6	5	44	37
52101 & above	12	12	3	2	15	13
Total	101	100	127	100	119	100

Table 6.15 shows that the modal income range for Mariannhill Park is R3201 – 12800 (36%), while it is R401 – 3200 (40%) for Nazareth and R12801 – 51200 (37%) for Westville Central. More importantly 28% of households in Mariannhill Park earn less than the modal income range, while 34% of those in Nazareth earn less than the modal income range even though that range is lower than Mariannhill Park. For Westville Central, 50% of the respondents earn more than the modal income range for Mariannhill. This comparison between the three areas shows that income levels are lower than in Nazareth than in Mariannhill Park, and both are lower than Westville Central. A correlation analysis, non-parametric due to the non-probabilistic nature of the Westville sample, showed that there was a significant correlation between income (rho = -0.517, N = 347, $p < 0.0005$) and the area concerned. The correlation is reported at a 99% level of confidence. Hence it can be concluded that Nazareth is relatively low-income, Mariannhill is relatively middle income and Westville Central is relatively high income.

Apart from the comparison of income levels between the three areas, the income levels are also taken to be relative due to the fact that the representation of the income groups is different between the sample and population for Mariannhill Park, while there is no difference in Nazareth in income levels to those presented in Table 6.10. For Mariannhill Park however, the R38401 – 153600 income group is underrepresented in the sample, while the other groups are slightly overrepresented. This means the analysis presented in the sections that follows is biased towards the lower and higher income groups for Mariannhill Park.

6.5.2.1 Waste minimisation and attitude towards recycling

Factor analysis was conducted for questions dealing with waste minimisation behaviour (questions 9 – 12) and the reliability coefficient (Alpha-Cronbach) for these factors was found to be 0.572 for Mariannhill Park and 0.577 for Nazareth. Both reliability coefficients were found to be less than the minimum level of 0.6 which is expected for exploratory studies in social behaviour such as this one (Popat, 2003; Cristein-Weiss et al., 2005). Incidentally, a minimum reliability coefficient of 0.7 is set for established social behaviour studies (Tonglet et al., 2003; Cristein-Weiss et al., 2005). These results were not used in further analysis for both Mariannhill Park and Nazareth. The reliability coefficients for attitude towards recycling (questions 13 – 20) were also lower than the minimum: Alpha-Cronbach = 0.271 for Mariannhill Park and Alpha-Cronbach = 0.191 for Nazareth. The low reliability coefficients could be accounted for by the fact that in both sample areas, isiZulu speakers accounted for at least 50% of the respondents, and there was a language barrier to overcome among these respondents, especially when questions had to be rephrased by the interview facilitators. Comparison of these reliability coefficients with those from Westville Central (Alpha-Cronbach = 0.668 for waste minimisation and Alpha-Cronbach = 0.257), shows that while language may have been a factor with waste minimisation, recycling attitude could have been affected by other factors since its coefficients are very low for all three areas.

6.5.2.2 Willingness to recycle

The descriptive statistics for willingness to recycle are shown in Table 6.16. The table shows that more than 84% of households in both areas are willing to recycle their household waste. Also most households have indicated that they would be willing to recycle the materials earmarked for the recycling scheme, with levels for the materials equal to or higher than the willingness to recycle. In Mariannhill Park, however, the levels for willingness to recycle plastic (79%) and cans (78%) are lower than for paper and glass. This difference is not considered to be significant given that the difference is 5% or less. Overall, it is estimated that a minimum of 84% (+/-6.53%) of households would be willing recycle their household waste in both areas. And this willingness to recycle is independent of the average income level of the community.

Although willingness to recycle is independent of the level of income for Mariannhill Park and Nazareth, further analysis of Table 6.16 shows that willingness to recycle for Westville

Central is higher than both areas on all accounts. Chi-Square tests (α = 0.05) were carried out for all the three areas and the results indicated that willingness to recycle was significantly different between the three areas, with willingness to recycle glass being the same for all areas. This means that high income areas are more willing to recycle than middle and low income areas. The results for the Chi-Square tests for willingness to recycle, including the various fractions are shown in Table 6.17.

Table 6.16: Descriptive statistics for Willingness to Recycle

		Response (%)			
	Region	**No**	**Unsure**	**Yes**	**Total**
Question 24	Mariannhill Park	10	6	84	100
	Nazareth	9	6	85	100
	Westville Central	8	-	92	100
Question 26	Mariannhill Park	8	8	84	100
	Nazareth	8	7	85	100
	Westville Central	3	-	97	100
Question 27	Mariannhill Park	8	8	84	100
	Nazareth	9	8	84	100
	Westville Central	2	4	94	100
Question 28	Mariannhill Park	13	8	79	100
	Nazareth	10	4	86	100
	Westville Central	1	6	93	100
Question 29	Mariannhill Park	11	11	78	100
	Nazareth	9	2	89	100
	Westville Central	3	-	97	100

Table 6.17: Summary of Chi-Square Test results for Willingness to Recycle

	χ^2_{test}	**df**	**p**	χ^2_{std}	**α**	**Decision**
Question 24	12.410	4	0.015	9.49	0.05	Reject Ho
Question 26	12.758	4	0.013	9.49	0.05	Reject Ho
Question 27	8.209	4	0.084	9.49	0.05	Cannot reject Ho
Question 28	14.400	4	0.006	9.49	0.05	Reject Ho
Question 29	22.911	4	0.000	9.49	0.05	Reject Ho

The results of the hypothesis testing indicated that only one of the independent variables, Home Language had significant differences within its categories with regards to willingness to recycle (χ^2 = 13.672, df = 4, p = 0.008) for Mariannhill Park. Conversely, only age had significant differences (χ^2 = 10.397, df = 4, p = 0.034) within its categories with regards to willingness to recycle. It could be argued that due to the high rate of willingness to recycle (84% and above), in both Mariannhill Park and Nazareth, the differences between the various categories within the independent variables have been masked. As a result, willingness to recycle is not significantly affected by the various demographic factors measured in the survey. The results for all the tests are summarised in Table 6.18.

Table 6.18: Summary of Hypothesis Tests with regards to Willingness to Recycle

Mariannhill Park					
Variable	**Test**	**Statistics**			**Significance***
Gender	Independent t	t = 0.472	df* = 98	p = 0.638	**No**
Age	Kruskal - Wallis	χ^2 = 3.110	df = 4	p = 0.540	**No**
Home Language	Kruskal - Wallis	χ^2 = 13.672	df = 4	p = 0.008	**Yes**
Type of Dwelling	Kruskal - Wallis	χ^2 = 0.769	df = 3	p = 0.857	**No**
No. of Occupants	Correlation	rho = 0.163	N = 101	p = 0.104	**No**
Income	Correlation	rho = 0.023	N = 101	p = 0.823	**No**
Nazareth					
Variable	**Test**	**Statistics**			**Significance**
Gender	Independent t	t = 0.200	df = 125	p = 0.842	**No**
Age	Kruskal - Wallis	χ^2 = 10.397	df = 4	p = 0.034	**Yes**
Home Language	Kruskal - Wallis	χ^2 = 3.203	df = 4	p = 0.525	**No**
Type of Dwelling	Kruskal - Wallis	χ^2 = 0.775	df = 3	p = 0.855	**No**
No. of Occupants	Correlation	rho = -0.024	N = 127	p = 0.079	**No**
Income	Correlation	rho = 0.002	N = 127	p = 0.985	**No**

*df – degrees of freedom; p – significance level (95% l.o.s)

6.5.2.3 Willingness to source separate

The descriptive statistics for willingness to source separate are shown in Table 6.19. The table shows that more than 73% of households in both Mariannhill Park and Nazareth are willing to recycle their household waste. Also most households have indicated that they would be willing to source separate if DWS collected the recyclables at no cost to the households. This result should be treated with caution as less than 30% of households did not indicate their preferred method of collection. Overall, it is estimated that a minimum of 73% (+/-6.53%) of households would be willing to source separate their household waste in both areas. And this willingness to source separate is independent of the average income level of the community.

Table 6.19: Descriptive statistics for Willingness to Source-separate

		Response (%)			
	Region	**No**	**Unsure**	**Yes**	**Total**
Question 25 a)	Mariannhill Park	13	13	74	100
	Nazareth	10	17	73	100
	Westville Central	4	8	87	100
		Landfill	**Single Point**	**DSW Collection**	**Total**
Question 25 b)	Mariannhill Park	17	18	65	100
	Nazareth	4	30	66	71
	Westville Central	5	14	81	87

Although willingness to source separate is independent of the level of income for Mariannhill Park and Nazareth, further analysis of Table 6.17 shows that willingness to source separate in Westville Central (87%) is higher than both areas. Chi-Square tests (α = 0.05) were carried out for all the three areas and the results indicated that the willingness to source separate was significantly different between the three areas. This means that high income areas are more willing to source separate than middle and low income areas. This conclusion is similar to that reached for willingness to recycle. The results for the Chi-Square tests for willingness to source separate are shown in Table 6.20.

Table 6.20: Summary of Chi-Square Test results for At-source Separation

	χ^2_{test}	df	p	χ^2_{std}	α	Decision
Question 25 a)	10.566	4	0.032	9.49	0.05	Reject Ho
Question 25 b)	27.931	4	0.000	9.49	0.05	Reject Ho

The results of the hypothesis testing indicated that only two of the independent variables, Age (χ^2 = 11.089, df = 4, p = 0.026) and Home Language (χ^2 = 15.834, df = 4, p = 0.003) had significant differences (at 95% l.o.s) within their categories with regards to willingness to recycle for Mariannhill Park. Conversely, only type of dwelling had significant differences within its categories (χ^2 = 10.397, df = 4, p = 0.034) with regards to willingness to source separate in Nazareth. It could be argued that because of lower rate of willingness to source separate, more of the differences within the independent variables were unmasked as compared with willingness to recycle. It can then be concluded that at low levels of willingness to recycle or source separate, the differences arising from demographic factors will be clearly distinguishable in both areas. The results for all the tests are summarised in Table 6.21.

It is important to note that the results for willingness to recycle and source separate were used in scenario 1b) in the Environmental Assessment discussed in Section 6.4. The validity of using those figures has been demonstrated in this section.

6.6 Economical assessment

The purpose of this section is to assess economical benefits of the application of the proposed ZWS in Mariannhill Park and Nazareth. This assessment employs the use of the cost benefit analysis (CBA) and compares the costs associated with the base case scenario and the other four scenarios identified in Section 6.4. As mentioned in Section 4.5.4, the CBA is influenced by the price of recyclables, thus a high profit and low profit cases were investigated. The discussion on the price of recyclables follows in the next section, while the CBA outcomes for all the scenarios identified in Section 6.4 will be discussed in Section 6.6.2.

Table 6.21: Summary of Hypothesis Tests with regards to Willingness to Recycle

Mariannhill Park					
Variable	**Test**	**Statistics**			**Significance**
Gender	Independent t	t = 0.996	df = 75	p = 0.322	**No**
Age	Kruskal - Wallis	χ^2 = 11.089	df = 4	p = 0.026	**Yes**
Home Language	Kruskal - Wallis	χ^2 = 15.834	df = 4	p = 0.003	**Yes**
Type of Dwelling	Kruskal - Wallis	χ^2 = 1.350	df = 3	p = 0.717	**No**
No. of Occupants	Correlation	rho = 0.026	N = 101	p = 0.795	**No**
Income	Correlation	rho = 0.007	N = 101	p = 0.943	**No**
Nazareth					
Variable	**Test**	**Statistics**			**Significance**
Gender	Independent t	t = 1.343	df = 125	p = 0.182	**No**
Age	Kruskal - Wallis	χ^2 = 1.057	df = 4	p = 0.901	**No**
Home Language	Kruskal - Wallis	χ^2 = 5.330	df = 4	p = 0.255	**No**
Type of Dwelling	Kruskal - Wallis	χ^2 = 10.436	df = 3	p = 0.015	**Yes**
No. of Occupants	Correlation	rho = 0.063	N = 127	p = 0.481	**No**
Income	Correlation	rho = -0.009	N = 127	p = 0.919	**No**

6.6.1 Recyclables prices

The average prices of recyclables in Durban over a five year period (2001 – 2005) are presented in Table 6.22. The table shows that the price for recyclables, for all material types, fluctuates considerably over the years shown and the prices from any year cannot be used to predict those for the following year. Statistical analysis of each material indicates that the price for glass, with a coefficient of variation of 0.19, has shown the most stability, while that for paper, with a coefficient of variation of 0.48, has shown the most volatility. This means that the total price of recyclables will be affected most by the price of paper and least by the price of glass given the relative proportion of the recyclables within the waste streams.

Table 6.22: Average prices for recyclables in Durban (2001 – 2005) (Source: Mgingqizana, 2006)

	Price [R/kg]				
Recyclable	**2001**	**2002**	**2003**	**2004**	**2005**
Cardboard	0.25	0.30	0.35	0.45	0.15
Magazines + Newspaper	0.10	0.15	0.20	0.20	0.05
Computer paper	0.60	0.65	0.65	0.80	0.10
Low Density Plastic	0.50	0.60	0.65	0.80	0.80
High Density Plastic	No market for HDP in Durban				0.50
Ferrous metals	0.30	0.35	0.40	0.50	0.75
Glass	0.05	0.10	0.10	0.10	0.10

Table 6.22 (Continued)

Recyclable	Mean	Maximum	Minimum	Standard Deviation	Co-efficient of Variation
Cardboard	0.30	0.45	0.15	0.11	0.37
Magazines + Newspaper	0.14	0.20	0.05	0.07	0.47
Computer paper	0.56	0.80	0.10	0.27	0.48
Low Density Plastic	0.67	0.80	0.50	0.13	0.19
High Density Plastic	0.50	0.50	0.50		0.00
Ferrous metals	0.46	0.75	0.30	0.18	0.39
Glass	0.09	0.10	0.05	0.02	0.25

Whilst Table 6.22 gives the average commodity prices for Durban over a five year period, Table 6.23 gives the prices for recyclables at the Westmead Recycling Centre, which have been used to calculate the expected income that could be generated in the ZWS through the sale of recyclables. The prices in Table 6.23 are a record of the lowest and highest prices for a given recyclable material for the year of analysis. The set of the low prices has been used to calculate the least expected revenue that could be generated from the sale of recyclables. This is termed the low profit case in the CBA. The high profit case in turn, uses the set of high prices to calculate the highest expected revenue from the sale of recyclables. It is important to note that the expected profit range could be exceeded in each case given the coefficients of variation shown in Table 6.22. The spot commodity prices for the Westmead Recycling Centre (2005) shown in Table 6.12 are evidence of this behaviour.

Table 6.23: Selling prices for recyclables at Westmead Recycling Centre (2003 - 2004) (Source: Mgingqizana, 2006)

Recyclable	**2003**		**2004**	
	Low	**High**	**Low**	**High**
Cardboard	0.35	0.40	0.15	0.45
Magazines + Newspaper	0.20	0.20	0.10	0.20
Computer paper	0.65	0.70	0.10	0.80
Low Density Plastic	0.60	0.60	0.80	1.00
Ferrous metals	0.35	0.35	0.50	0.50
Glass	0.05	0.10	0.05	0.05

6.6.2 Cost benefit analysis

The CBA results for scenarios 1a) and 1b) for 2003 will be discussed in this section along with the summaries for 2003 and 2004 for all scenarios. The full set of calculations is attached in Appendix B.4.

6.6.2.1 Scenario 1a)

The CBA results for scenario 1a) are given in Tables 6.24, 6.25 and 6.26 for the high profit case and Tables 6.27, 6.28 and 6.29 for the low profit case. It should be borne in mind that scenario 1a) represents an operational ideal for at-source separation: full capture of all recyclables, maximum participation by households and with all households in the area taking part in the recycling scheme. Tables 6.24 and 6.27 show the total mass and volume, along with revenue of recyclables that could be generated, , in the high and low profit cases respectively, by the proposed ZWS in 2003. For the same period, Table 6.25 and 6.28 show the CBA calculations for the high and low profit cases respectively, while Table 6.26 and 6.29 show the Benefit/Cost of capital ratio. This ratio is another measure of the worthwhileness of the proposed ZWS and a ratio greater than one indicates worthwhileness (Paschke and Hatcher, 1991; DEAT, 2004).

Table 6.24 shows a summary of the waste generated in Mariannhill Park and Nazareth and the recyclables that could be reclaimed from the waste stream if at-source separation is applied. As seen from the table, the recyclable mass is greater than the disposable one. This is due to the fact that the waste stream in both areas contains a greater fraction of

Table 6.24: Domestic waste generation for proposed ZWS (Scenario 1a) – 2003: High Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	922 tons	255 tons	1177 tons	980 m^3
Recyclable	489 tons	176 tons	665 tons	554 m^3
Disposable	433 tons	79 tons	512 tons	427 m^3
Revenue	**R 235,755**	**R 88,360**	**R 321,115**	

recyclables than the disposable waste. Also, the revenue that could be generated from the sale of recyclables is given in the table. This revenue is the only direct economic benefit associated with the application of the proposed ZWS. However, the overall economic benefit associated with the proposed ZWS is the reduced costs of operation as compared with the current costs. This can be seen in Table 6.25.

Table 6.25 shows that for 1176 tons of waste generated in Mariannhill Park and Nazareth, total cost saving of R164, 789 could be achieved when 664 tons of waste is diverted way from the landfill. This cost saving amounts to R248/ton and is an indication that the application of the proposed ZWS in the two areas would be worthwhile. The worthwhileness of the proposed ZWS can also be seen in the net benefit/capital ratio of 3.3 as shown in Table 6.26. Despite this positive outcome, it should be noted that the cost saving is a result of the sale of the recyclables that would be collected in the proposed ZWS. This means that the worthwhileness of the proposed ZWS is based on the availability of markets for the recyclables and the prices that the recyclables can be sold at. A lack of markets or very low prices would render the proposed ZWS economically unsustainable. Since markets for the recyclables do exist in Durban, the main determinant in the economic feasibility of the proposed ZWS is the prices for each recyclable material. Although the prices fluctuate considerably as shown in Table 6.22, the actual prices for the year of analysis showed that the proposed ZWS would be economically viable.

Table 6.25: Cost Benefit Analysis for 2003 (Scenario 1a) – High Profit)

		Quantity	Rate	Amount
Current Operation				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	980 m^3	R27.35/m^3	R 26,813
	Operational	980 m^3	R92.55/m^3	R 90,736
Total Costs				**R 352,838**
Recycling Scheme				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	427 m^3	R27.35/m^3	R 11,674
	Operational	427 m^3	R92.55/m^3	R 39,504
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	664 tons	R70/ton	R 46,498
	Marketing Campaigns	3250 Houses	R10/house	R 32,500
	Dual Containers	3250 Bins	R10/Bin	R 32,500
	Collection Bags	340000 Bags	R0.18/bag	R 61,200
Scheme Benefits	Sale of recyclables			-R 321,115
Total costs				**R 188,049**
Total Savings				**R 164,789**

Table 6.26: Benefit/Cost ratio (Scenario 1a) – 2003: High Profit)

Net Benefit	R 164,789
Capital	R 50,000
Net Benefit/Capital	3.3

Table 6.27: Domestic waste generation for proposed ZWS (Scenario 1a) - 2003: Low Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	922 tons	255 tons	1177 tons	980 m^3
Recyclable	489 tons	176 tons	665 tons	554 m^3
Disposable	433 tons	79 tons	512 tons	427 m^3
Revenue	**R 185,282**	**R 69,389**	**R 254,671**	

Table 6.27 shows the same results to those shown in Table 6.24, with the only difference being the revenue generated from the sale of recyclables. This revenue is lower than that in Table 6.24 since it uses lowest recyclables prices attained during the year of analysis. This revenue is the only direct economic benefit associated with the application of the proposed ZWS. However, the overall economic benefit associated with the proposed ZWS is the reduced costs of operation compared with the current costs. This can be seen in Table 6.28.

Table 6.28 shows that for 1176 tons of waste generated in Mariannhill Park and Nazareth, total cost saving of R98,345 could be achieved when 664 tons of waste is diverted way from the landfill. The cost saving amounts to R148/ton and is an indication that the application of the proposed ZWS in the two areas would be worthwhile. The worthwhileness of the proposed ZWS can also be seen in the net benefit/capital ratio of 2.0 as shown in Table 6.29. This result is the lower bound of the expected worthwhileness of the proposed ZWS for scenario 1a).

Table 6.28: Cost Benefit Analysis for 2003 (Scenario 1a) – Low Profit)

		Quantity	Rate	Amount
Current Operation				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	980 m^3	R27.35/m^3	R 26,813
	Operational	980 m^3	R92.55/m^3	R 90,736
Total Costs				**R 352,838**
Recycling Scheme				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	427 m^3	R27.35/m^3	R 11,674
	Operational	427 m^3	R92.55/m^3	R 39,504
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	664 tons	R70/ton	R 46,498
	Marketing Campaigns	3250 Houses	R10/house	R 32,500
	Dual Containers	3250 Bins	R10/Bin	R 32,500
	Collection Bags	340000 Bags	R0.18/bag	R 61,200
Scheme Benefits	Sale of recyclables			-R 254,671
Total costs				**R 254,493**
Total Savings				**R 98,345**

Table 6.29: Benefit/Cost ratio (Scenario 1a) – 2003: Low Profit)

Net Benefit	R 98,345
Capital	R 50,000
Net Benefit/Capital	2.0

6.6.2.2 Scenario 1b)

The CBA results for scenario 1b) are given in Tables 6.30, 6.31 and 6.32 for the high profit case and Tables 6.33, 6.34 and 6.35 for the low profit case. It should be borne in mind that scenario 1b) represents a realistic operation for at-source separation: capture of recyclables and participation by households as measured in the Social Assessment. Tables 6.30 and 6.33 show the total mass and volume of recyclables that could be generated by the proposed ZWS in 2003 in the high and low profit cases respectively. For the same period, Table 6.31 and 6.34 show the CBA calculations for the high and low profit cases respectively, while Table 6.32 and 6.35 show the Benefit/Cost of Capital ratio.

Table 6.30: Domestic waste generation for proposed ZWS (Scenario 1b) – 2003: High Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	922 tons	255 tons	1176 tons	980 m^3
Recyclable	304 tons	109 tons	413 tons	344 m^3
Disposable	618 tons	146 tons	764 tons	636 m^3
Revenue	**R 144,681**	**R 54,827**	**R 199,508**	

Table 6.30 shows a summary of the waste generated in Mariannhill Park and Nazareth and the recyclables that could be reclaimed from the waste stream if at-source separation is applied. As seen from the table, the recyclable mass is less than the disposable one. This is due to the effect of the participation rate of households in the proposed ZWS and the capture rate of recyclables by households. As discussed in Sections 6.5.2.3 and 6.5.2.4, these rates are 73% and 85% respectively, hence the lower yield of recyclables compared with scenario 1a). Similarly, the revenue that could be generated from the sale of recyclables is lower than that for scenario 1a) as a result of the effect of household participation rate and capture rate. Moreover, this revenue is the only direct economic benefit associated with the application of the proposed ZWS. However, the overall economic benefit associated with the proposed ZWS is the reduced costs of operation as compared with the current costs as shown in Table 6.31.

Table 6.31: Cost Benefit Analysis for 2003 (Scenario 1b) - High Profit)

		Quantity	Rate	Amount
Current Operation				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	980 m^3	R27.35/m^3	R 26,813
	Operational	980 m^3	R92.55/m^3	R 90,736
Total Costs				**R 352,838**
Recycling Scheme				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	636 m^3	R27.35/m^3	R 17,407
	Operational	636 m^3	R92.55/m^3	R 58,905
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	413 tons	R70/ton	R 28,890
	Marketing Campaigns	2405 Houses	R10/house	R 24,050
	Dual Containers	2405 Bins	R10/bins	R 24,050
	Collection Bags	251600 bags	R0.18/bag	R 45,288
Scheme Benefits	Sale of recyclables			-R 199,508
Total costs				**R 284,370**
Total Savings				**R 68,468**

Table 6.31 shows that for 1176 tons of waste generated in Mariannhill Park and Nazareth, total cost saving of R68, 468 could be achieved when 413 tons of waste is diverted way from the landfill. The cost saving amounts to R166/ton and is an indication that the application of the proposed ZWS in the two areas would be worthwhile. The worthwhileness of the proposed ZWS can also be seen in the net benefit/capital ratio of 1.4

as shown in Table 6.32. Although the proposed ZWS is worthwhile, it is clear that the cost saving achieved is much lower than the ideal case of at-source separation. This decrease in cost saving emphasises the sensitivity of scenario 1b) to changes in participation rates and recyclables capture rate. This means that a change of one percent in either factor will lead to a change of more than one percent in the cost saving. Consequently, a 50% participation rate and a 50% capture rate would render the proposed ZWS economically non-viable.

Table 6.32: Benefit/Cost ratio (Scenario 1b) - 2003: High Profit)

Net Benefit	R 68,468
Capital	R 50,000
Net Benefit/Capital	1.4

Table 6.33 shows a summary of the waste generated in Mariannhill Park and Nazareth and the recyclables that could be reclaimed from the waste stream if at-source separation is applied. The table is similar to Table 6.30, with the exception that the revenue from the sale of recyclables is lower than that in Table 6.30. This is as a result of using the lower bound of recyclables prices. The effect of using these prices can be seen in the cost savings achieved for this scenario as shown in Table 6.34.

Table 6.33: Domestic waste generation for proposed ZWS (Scenario 1b) - 2003: Low Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	922 tons	255 tons	1176 tons	980 m^3
Recyclable	304 tons	109 tons	413 tons	344 m^3
Disposable	618 tons	146 tons	764 tons	636 m^3
Revenue	**R 115,171**	**R 43,056**	**R 158,227**	

Table 6.34 shows that for 1176 tons of waste generated in Mariannhill Park and Nazareth, total cost saving of R27, 187 could be achieved when 413 tons of waste is diverted way from the landfill. The cost saving amounts to R66/ton and is an indication that the application of the proposed ZWS in the two areas would be worthwhile. In terms of return on capital, the low profit case for Scenario 1b falls beneath the expected rate of return as indicated by the net benefit/capital ratio of 0.5 shown in Table 6.35. As shown by the net benefit/capital ratio, a decrease in the measured participation rate or the capture rate can

render the proposed ZWS economically unviable given that there will be no return on the capital invested in the ZWS. This is despite the fact that the proposed ZWS will still achieve cost savings compared with current operational costs. Thus the return on capital is another factor limiting the economic viability of the proposed ZWS, though it is not a critical factor in this case given that waste management is a public service rather that a private one.

Table 6.34: Cost Benefit Analysis for 2003 (Scenario 1b) – Low Profit)

		Quantity	Rate	Amount
Current Operation				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	980 m^3	R27.35/m^3	R 26,813
	Operational	980 m^3	R92.55/m^3	R 90,736
Total Costs				**R 352,838**
Recycling Scheme				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	636 m^3	R27.35/m^3	R 17,407
	Operational	636 m^3	R92.55/m^3	R 58,905
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	413 tons	R70/ton	R 28,890
	Marketing Campaigns	2405 Houses	R10/house	R 24,050
	Dual Containers	2405 Bins	R10/bins	R 24,050
	Collection Bags	251600 Bags	R0.18/bag	R 45,288
Scheme Benefits	Sale of recyclables			-R 158,227
Total costs				**R 325,651**
Total Savings				**R 27,187**

Table 6.35: Benefit/Cost ratio (Scenario 1b) – 2003: Low Profit)

Net Benefit	R 27,187
Capital	R 50,000
Net Benefit/Capital	0.5

6.6.2.3 Cost savings comparison

Whilst the 2003 economic results for scenarios 1a) and 1b) have been discussed in the preceding sections, this section will focus on the overall economic results for all the scenarios investigated. The results include the high profit and low profit cases for both years of analysis. The results for the high profit case are presented in Table 6.36 while those for the low profit case are presented in Table 6.37. As highlighted in Section 6.6.2, the full set of calculations for all the scenarios are attached in Appendix B.4.

Table 6.36: Scenario cost saving per unit of solid waste – High Profit (2003 and 2004)

2003						
Scenario	**Mass [tons]**	**Volume [m^3]**	**Saving [R]**	**Savings [R per ton]**	**Savings [R per m^3]**	**Net Benefit/ Capital Ratio**
1 a)	664	554	164,789	248	298	3.3
1 b)	413	344	68,468	166	199	1.4
2	353	294	0	0	0	-
3	280	233	71,722	256	307	1.4
2004						
Scenario	**Mass [tons]**	**Volume [m^3]**	**Saving [R]**	**Savings [R per ton]**	**Savings [R per m^3]**	**Net Benefit/ Capital Ratio**
1 a)	703	586	303,296	432	518	6.1
1 b)	437	364	154,528	354	425	3.1
2	375	312	0	0	0	-
3	297	248	107,669	362	435	2.2

Table 6.37: Scenario cost saving per unit of solid waste – Low Profit (2003 and 2004)

2003						
Scenario	**Mass [tons]**	**Volume [m³]**	**Saving [R]**	**Savings [R per ton]**	**Savings [R per m³]**	**Net Benefit/ Capital Ratio**
1 a)	664	554	98,345	148	178	2.0
1 b)	413	344	27,187	66	79	0.5
2	353	294	0	0	-	-
3	280	233	36,105	129	155	0.7
2004						
Scenario	**Mass [tons]**	**Volume [m³]**	**Saving [R]**	**Savings [R per ton]**	**Savings [R per m³]**	**Net Benefit/ Capital Ratio**
1 a)	703	586	146,866	209	225	2.9
1 b)	437	364	57,341	131	158	1.1
2	375	312	0	0	0	-
3	297	248	24,648	83	100	0.5

Both Tables 6.36 and 6.37 show that scenario 1a) achieves the highest cost savings per unit of recycled waste in both years of analysis. These cost savings represent the operational ideal for at-source separation for the proposed ZWS. Furthermore, the net benefit/cost of capital ratios are also the highest for scenario 1a), showing that this scenario achieves a high rate of return on the capital invested. However, at-source separation for the proposed ZWS is expected to yield the results attained in scenario 1b). These cost savings are higher than either scenarios 2 and 3, and are an indication of the economic benefits that could be gained by applying at-source separation.

Looking at both Tables 6.36 and 6.37, it will be noticed that scenario 2 does not generate any saving for the amount of waste recycled. This lack of cost saving is as a result of recyclers collecting the recyclables directly from households and transporting them directly to processing plants. Thus the recyclers do not pay for the recyclables and only have to pay for collection and transportation costs. Thus current ad-hoc recycling initiatives take place at no extra cost to recyclers or households. However, comparison of scenario 1a and 1b with scenario 2 shows that the proposed ZWS will have a greater economic benefit than the ad-hoc initiatives, but at a high cost of capital investment than present in the ad-hoc initiatives. These high capital costs can be justified on the basis that they divert greater waste from the landfill thereby extending the lifespan of the landfill and also educate households about their responsibility for the waste that they generate. This awareness could be used as a motivational tool in getting households to practice waste minimisation behaviour as required in the zero waste model. Moreover, at-source separation of recyclables is a more sustainable way of dealing with waste compared with mixed-waste recycling presented by scenario 3 and ad-hoc recycling represented in scenario 2.

6.6.3 CBA summary

The overall results of the economic analysis for the proposed ZWS that incorporates Mariannhill Park and Nazareth are shown in Table 6.38 for the high profit case and in Table 6.39 for the low profit case. In both cases, the results show that environmental and economic benefits will be gained due to the application of the proposed ZWS. Environmental benefits are shown in the landfill volume space that could be conserved as a result of the non-disposal of recyclables at the Mariannhill Landfill site. Direct economic benefits arise from the sale of recyclables, while indirect benefits are the cost savings that would result as waste is recycled rather than disposed. These cost savings range from R340/ton to R260/ton in the high profit case and R179/ton to R99/ton in the low profit case for scenarios 1a and 1b. The difference between the two cases is the prices at which the recyclables are sold to recyclers. Although the cost savings range from R309/ton to R106/ton for both profit cases in scenario 3, it was shown in Chapter that mixed-waste recycling is a non-starter in South Africa. In conclusion, it has been shown that the application of the proposed ZWS in Mariannhill Park and Nazareth would be economically worthwhile. What remains to be seen is whether the waste management service provider, DSW in this case, has the institutional capacity to implement the proposed ZWS. This assessment will carried out in the next section.

Table 6.38: Summary of results for Zero Waste Scheme – High Profit (2003 and 2004)

Scenario	1 a)	1 b)	2	3
Total MSW (tons)	2425	2425	2425	2425
Disposed MSW (tons)	1058	1575	1698	1848
Total Recyclables (tons)	1367	850	727	577
Revenue (Recyclables)	R777,721	R483,202	-	R301,735
Air Space Saving (m^3)	1137	708	606	481
CBA - Total Benefit	R468,085	R222,996	0	R179,391
Mass Cost Saving (R/ton)	340	260	0	309
Volume Cost Saving (R/ m^3)	408	312	0	371

Table 6.39: Summary of results for Zero Waste Scheme – Low Profit (2003 and 2004)

Scenario	1 a)	1 b)	2	3
Total MSW (tons)	2425	2425	2425	2425
Disposed MSW (tons)	1058	1575	1698	1848
Total Recyclables (tons)	1367	850	727	577
Revenue (Recyclables)	R554,487	R344,734	-	R183,097
Air Space Saving (m^3)	1137	708	606	481
CBA - Total Benefit	R245,211	R84,528	0	R60,753
Mass Cost Saving (R/ton)	179	99	0	106
Volume Cost Saving (R/ m^3)	214	118	0	127

6.7 Institutional assessment

As mentioned in Section 4.5.5, the Institutional Assessment focuses on the ability of the eThekwini Municipality, through DSW, to effectively implement and manage the proposed ZWS. The assessment is carried using the IAD Framework identified in Section 4.2.4: efficiency, equity, accountability, policy outcomes and adaptability. These criteria will be applied to DSW as the main service provider of waste management services in the case study areas, and where applicable, to the eThekwini Municipality since DSW is closely integrated into it. The main sources of information for this assessment are the Integrated development plan [IDP] (2003 – 2008) for the eThekwini Municipality (2003) and the Integrated waste management plan [IWMP] (SKC, 2004).

6.7.1 Efficiency

In terms of efficiency, the eThekwini Municipality has historically been measured on its financial management rather than the extent to which it has met developmental goals (eThekwini, 2003). Using the benchmark of financial management alone can lead to the municipality being efficient in other areas, which in turn leads to it being bureaucratic in nature, hence administratively inefficient since that aspect is not being measured. The inefficiency of the municipality has in turn affected DSW as it is closely linked to the municipality. This can be seen in the fact that DSW is not ring fenced from other business units of the municipality (SKC, 2004), which means that strategic decisions that need to be made concerning its plans have to approved by the municipality before they can be implemented. This arrangement has many drawbacks (SKC, 2004): DSW is not high enough on the operational and capital budget allocation priorities of the municipality, hence there is a delay in funding projects due to competing priorities; there is lack of understanding of waste management business at a senior and political level within the municipality, which results in waste management issues being assigned a low priority; service level agreements with customers cannot be entered into since DSW is a not a fully fledged business unit, thus resulting in inadequate monitoring of services rendered and the solid waste management information is deficient and limited, hence it cannot inform management's decision making. This ultimately leads to some inefficiency in the management of the core function of DSW, which is the provision of waste management services.

The fact that DSW is not ring fenced also means that it is dependent on the municipality for financial resources. This fact is highlighted in the IWMP (SKC, 2004), which shows that DSW is a sub-cluster within the municipality and all its financial policies and procedures are subject to that of the municipality. The implication of this institutional arrangement is that DSW is not given enough finances to carry out its planned capital projects, despite the fact that it has the necessary skills and expertise to implement these projects (SKC, 2004). This is shown in Table 6.40 where the required finance for capital projects is compared with the allocated funds from the municipality.

Table 6.40: Capital Funding allocations for DSW from the Municipal Budget (Source: IDP, 2003 & IWMP, 2004)

Year	Allocated Capital Funding (R)	Required Capital funding (R)
2004/2005	31,618,800	39,784,290
2005/2006	34,253,280	58,407,187

It can be seen from Table 6.40 that the allocated funds are less than the required funds for capital expenditure. As noted in IWMP (SKC, 2004), the lower than needed capital allocation will compromise service delivery, of which the real impact will be seen in the medium to long term through increased operating costs and future capital expenditure. Moreover, DSW cannot raise funds to supplement the capital allocations as waste collection tariffs are integrated with rates and taxes, which are collected by the Municipality (SKC, 2004). These tariffs are further complicated by the fact they are not calculated according to the requirements of the Local Government Municipal Systems Act (SKC, 2004), thus making it difficult to determine the true cost of the services rendered and the revenue that should accrue to DSW from the municipality rates and taxes.

It can be seen from the preceding discussion that financial efficiency levels at DSW and the municipality are such that they negate the implementation of the proposed ZWS. And this is despite the fact that DSW has the technical skills and expertise to implement the proposed ZWS. This lack of funding is further compounded by the fact that decisions to implement the proposed ZWS have to be approved by the Municipality. As has been shown in the preceding financial assessment of the institutional arrangement between DSW and the municipality, the capital needs of DSW are not seen as a priority by the municipality. Furthermore, the implementation of the proposed ZWS will require an inflow of funds to sustain it in the initial set up. This need for funding may prove to be problematic since administrative inefficiencies can lead to delays in allocation of funding for projects. Finally, the implementation of the proposed ZWS will require stringent enforcement. This may also prove problematic as the municipality is unable to adequately enforce existing waste management by-laws (SKC, 2004).

6.7.2 Equity

According to the IDP (eThekwini Municipality, 2003), the focus of the municipality's development strategy is to achieve a balance between the need to distribute resources and opportunities to the previously disadvantaged as well as maintaining existing infrastructure and services. This means that development has to occur in an equitable, efficient and sustainable manner while ensuring that new development is balanced with rehabilitation and maintenance of existing infrastructure (eThekwini Municipality, 2003). Furthermore, these environmental services have to be extended to communities where they do not exist, and have to be provided free of charge when such communities cannot afford them (eThekwini Municipality, 2003). Following this principle, DSW has embarked on an expansion of the waste disposal service to un-serviced and under-serviced areas (SKC, 2004). These un-serviced areas include rural areas where there is an issue of accessibility. DSW has addressed the problem of accessibility by empowering community based entrepreneurs to collect waste in their communities (SKC, 2004). While this discussion has focused on redistributive equity, fiscal equity is also fully developed in that those who require waste management services have to pay for such services. However, as mentioned in Section 6.7.1, tariffs for waste collection services are included in the rates and taxes paid to the Municipality. Whether these tariffs are equitable or not cannot be easily assessed.

In terms of the application of the proposed ZWS, it can be seen that the equity principle seems also to negate its application. This conclusion is based on the premise that DSW is engaged in an expansion plan to un-serviced areas which may or may not be able to pay the tariffs for the service provided. Also, an under-funded capital expenditure budget means that application of the proposed ZWS is a lower priority than extending service delivery. The need for funding to implement and maintain the proposed ZWS could be addressed by increasing tariffs and diverting the surplus finances to fund the proposed ZWS. However, this is not practical as the tariffs are embedded in the rates and tax structure of the Municipality as highlighted in Section 6.7.1.Moreover, increasing tariffs essentially means that some households will be subsidising other households. This is in contradiction with the equity principle. Therefore unless funds can be secured externally to implement the proposed ZWS, it is seemingly not equitable to implement the proposed ZWS. This is more so when 25% of households in peri-urban areas, and more in rural areas of the Municipality (eThekwini Municipality, 2003), have no access to basic services such as waste collection and disposal.

6.7.3 Accountability

In section 4.2.4, accountability was defined as a principle that institutions should be held responsible for their actions. This is also a requirement of the Local Government Municipal Systems Act (Republic of South Africa, 2000) and the Municipality aims to achieve it by providing civil society with the opportunity to evaluate its performance (eThekwini Municipality, 2003): publicising key IDP targets; annual report backs at ward, regional and unicity level; publicising key performance contracts for top management and; annual IDP ward, stakeholder and unicity wide workshops. It is difficult to asses whether this is currently taking place, but if it is to any reasonable level, then the goal of accountability is being attained. It should be pointed out that this accountability process will be affected by political factors; these factors are beyond the scope of this assessment.

In terms of DSW, it has already been mentioned in Section 6.7.1 that service level agreements with customers cannot be entered into since DSW is a not a fully fledged business unit. This lack of service agreements means that accountability on the part DSW in its service provision is negated somewhat. However, this problem could be rectified through getting households to participate in meetings and forums set up by the Municipality. Furthermore, surveys could be carried out, within financial and administrative capacity of DSW, to find out whether the service being provided meets with the expectations of households and communities.

It is difficult to assess whether the principle of accountability can be applied to the implementation of the proposed ZWS. Essentially, this principle would need to be applied if DSW had asked whether households would be willing to participate in the proposed ZWS, and households had replied in the affirmative. However, this was not the case with the proposed ZWS as the views of households had been solicited to find out whether they would be willing to participate in the proposed ZWS, but DSW had made no pledge to implement the proposed ZWS. Irrespective of the arguments for or against the proposed ZWS in terms of accountability, it is clear that the proposed ZWS can proceed neither without the funding of DSW or the willingness of households to participate in it. In a way, the principle of accountability is embedded within such an arrangement.

6.7.4 Policy Outcomes and Adaptability

Policy outcomes and adaptability have been combined together since policies adopted by any institution will reflect whether the institution is able to adapt to changes in the environment within which it operates. The policy outcomes discussed in this section will be those that affect the proposed ZWS, that is, those that affect waste minimisation, at-source separation and recycling.

According to Section 75 of the Local Government Municipal Systems Act (Republic of South Africa, 2000), certain duties are placed on the municipality in relation to municipal services (SKC, 2004). This means that the municipality must give priority to the basic needs of the community and ensure that all members of the local community have access to at least the minimum level of basic municipal services. Furthermore, these services must be equitable and accessible; be provided in a way which promotes the prudent, economic, efficient and effective use of the available resources; be financially sustainable; be environmentally sustainable and; be regularly reviewed with a view of upgrading, extension and improvement. This is essentially the foundation for all DSW policy with regards to waste management services.

It can be seen that these foundational policies make it difficult to implement the proposed ZWS, especially when there are differing levels of service among households within the municipality. This means that priority has to be given to extending waste collection and disposal services to households that do not receive them before upgrading and improving the existing service among all households. In addition, the extension of the service to the previously unserviced households is already placing an economic burden on the municipality, which in turn cannot fulfil the capital requirements for providing the service. Also, the current way of disposing waste in engineered landfills is considered environmentally sustainable within the present economic climate of the municipality. This means that landfills are seen as the best way of making efficient and effective use of the available resources. These constraints have led DSW to conclude that zero waste, as delineated in the proposed ZWS, is virtually impossible within the eThekwini Municipality at present. This is the prevailing view put forward in the Integrated Waste Management Plan (SKC, 2004).

With regards to the different facets of the proposed ZWS, the following policy statements have been put forward in the IWMP (SKC, 2004):

1) Waste minimisation is contrary to the objective of a waste service provider, in that whereas the growth of business is a primary goal, waste minimisation results in reduced staff, equipment and turnover. However, growth in business, population and unit waste generation could neutralise this anomaly. These statements can essentially be interpreted to mean that waste minimisation is contrary to the goals of the waste service provider. They are also in contradiction with the statement that waste minimisation starts at home with the individual.
2) There is a general consensus that waste separation at source is not practical for a present day South African city with regard to domestic waste. Also, source separation will entail a massive education campaign over the time span of at least one generation for general waste. This is optimistic given that Community Development Workers, who undertake waste education within the municipality, are not employed on a permanent basis. However, it is stated that waste separation at source could be implemented in commercial and industrial applications and either financial rewards or penalty collection tariffs could be applied to create either incentives or disincentives. These statements can be interpreted to mean that waste minimisation can only be instituted for applications that are able to pay for the capital requirements for offering such a service as well as the maintenance costs of the service provided.
3) Recycling is also supported by DSW management because it is government policy and recycling in embodied in the National Waste Management Strategy (NWMS). Furthermore, the anomaly that results from increased and successful recycling, which is similar to that of waste minimisation, will have a destructive effect and impact on DSW's profit sustainability. This is considered a major reason why DSW must work towards becoming the primary facilitator of recycling in its area of operation. It can be seen that recycling will not be viable on a large scale within the municipality until DSW is ring fenced and allowed to operate as a fully fledged business unit. In the meantime, recycling will still be carried out on an ad hoc basis by material producers that operate within the municipality.
4) Zero Waste to landfill is not an attainable goal and certainly is not applicable to South Africa. This is due to the fact that South Africa has good landfill resources when compared to the USA and especially compared to European countries.

It can be concluded from the preceding discussion that the application of the proposed ZWS, based on the policy outcomes stated in the IWMP (SKC, 2004), cannot be undertaken in the case study areas. This conclusion is also based on the results of the institutional assessment using the other criteria. The effect of this result on the other sustainability assessment results will be discussed in the next section.

6.8 Discussion

This section is an evaluation of the sustainability assessment carried out on the proposed ZWS, the results of which have been presented in this chapter. It has to be remembered that the proposed ZWS evaluated in this chapter is based on the ZWM developed in Chapter 3. The ZWM was developed for post-consumer waste recyclables identified in Section 2.2.1.2. Also, it has to be pointed out that zero waste notionally implies the non-disposal of these materials in the landfill, but does not include the wet fraction arising in post-consumer household waste.

The environmental assessment showed that proposed ZWS could extend the life-span of the Mariannhill Landfill by a minimum of 30% for the worst case scenario investigated. This increase in life-span is due to the non-disposal of the recyclable fractions in the landfill as is the case now. Even more importantly, it has been shown that the landfill life-span could be increased by a factor of two if the recyclables are collected using at-source separation. This increase in life-span is due only to recycling and does not consider waste minimisation. Hence it is expected that a combination of waste minimisation and recycling would potentially increase the life-span of the landfill by more than a factor of two. It should be noted though that waste minimisation is limited by the environmental awareness of households, while recycling is limited by the available markets for the recyclables collected in the proposed ZWS. Both of these limitations can severely constrain the application of the proposed ZWS if they are not addressed.

Closely tied with at-source separation of recyclables is the willingness of households to participate in the proposed ZWS. From the results of the social assessment, it can be seen that households in the case study areas would be willing to source separate their waste. As noted by Hummel (2000), this involvement of households is critical to the success of the proposed ZWS. More importantly, the willingness of households to source separate their waste is independent of their income groups. This means that source separation behaviour is driven by other factors, income group not withstanding. As to what these factors are could not be revealed by the social assessment since most respondents did not fill in Question 8 in the questionnaire. This means that other assessments will have to be carried out with the specific objective of identifying whether the hypotheses proposed by Barr et al. (2001) are valid. But what is clear is that households are willing to source separate their waste, though this willingness could not be verified practically since the proposed ZWS was not implemented.

Despite this lack of practical application, it has been shown that the proposed ZWS is economically sustainable. However, its application is dependent on DSW or the Municipality providing the necessary capital funding. Without such funding, the proposed ZWS cannot be implemented. This is the main reason that it could not be implemented even if it had been shown theoretically that cost savings would be possible in its application. This cost savings would also be tied to the environmental awareness that would be spread among households in the implementation of the proposed ZWS. This is also the reason why scenario 3 was neglected even though they showed a cost saving potential. However, it should be pointed out that the long term economic sustainability of the proposed ZWS is based precariously on the availability of markets for the recyclables. As has been shown earlier in this discussion, such markets are unreliable. This fact is attested to by the volatility of the recyclables prices as shown in Table 6.22. While present markets could absorb the recyclables generated in the proposed ZWS, it is highly unlikely that they could absorb the recyclables generated by its application throughout the whole municipality.

While it has been shown in the other sustainability assessments that the proposed ZWS could be implemented with some constraints attached to it, the institutional assessment has shown that the biggest constraints are within the institutions required to fund and manage the ZWS. Basically the policy adopted by DSW is that source separation cannot be applied to household waste, while recycling is only possible when the markets are structured in DSW's interests. Since the institutional set up of DSW is such that it cannot operate as a business unit that is financially and administratively independent of the Municipality, the structuring of recycling markets to suit implementation of the proposed ZWS is not possible at present. It has also been shown that the priorities of the DSW, which is an expanded waste collection and disposal service, are such that the capital requirements of the proposed ZWS cannot be met at present. As a result, the proposed ZWS could not be implemented in the case study areas of Mariannhill Park and Nazareth.

6.9 Summary

In this chapter, the application of ZWM into an already established integrated waste management system has been discussed. Two communities adjacent to the Mariannhill landfill site were chosen for application of the proposed ZWS. It had been predicted that Mariannhill Park was a middle income area with a high level of service in terms of waste collection and disposal. Conversely, Nazareth was taken to be a low income area with an adequate level of service. However, the results of the study have shown that while the predicted income levels were correct relatively, the level of service has been shown to be the same for both areas. This service level is high in both areas, though the transportation vehicles for use in waste collection are different. These two areas were used to test the applicability of a proposed ZWS using the four sustainability criteria: environmental, social, economic and institutional. The results showed that while the proposed ZWS would be environmentally, socially and economically sustainable, albeit to differing degrees, it would not be institutionally sustainable. This lack of institutional sustainability is the main reason why the proposed ZWS was not implemented in the case study areas. The implications of this conclusion will be expanded on in the Chapter 7. Chapter 7 will focus attention on the implications of unsustainability in post-consumer waste in urban areas in general and the possible ways that these constraints can be dealt with in the move towards zero waste.

CHAPTER 7

7. TOWARDS A ZERO WASTE SOUTH AFRICA

7.1 Introduction

The purpose of this chapter is to propose guidelines for achieving zero waste in post-consumer waste in South Africa based on the results of the case studies. This will be done in three stages. Firstly, the results for Ndumo will be used inductively to arrive at general guidelines for application of zero waste in rural areas. Secondly, this process will also be applied to urban areas. Thirdly, these results will be synthesised to provide overall zero waste guidelines for application of zero waste in South Africa. In this way, a general notion of how far South Africa is in terms of achieving zero waste will be established. It should be borne in mind that these zero waste guidelines are being developed for the materials identified in section 2.2.2.1.

The layout of the chapter follows the analysis stages as presented above. This means that Sections 7.2, 7.3 and 7.4 will be an analysis of zero waste guidelines for rural areas, urban areas and South Africa respectively. Section 7.5 will be a general discussion of the possible strategies that can be used to overcome institutional unsustainability, which has been shown to be one of the main constraints to application of zero waste in South Africa, while Section 7.6 will be a summary of the chapter.

It should be pointed out that based on the reasons given in Section 3.5, rural areas and urban areas will also not be compared in assessing the possibility of achieving zero waste. Thus the assessment will be carried separately for rural and urban areas.

7.2 Zero waste in rural areas

The aim of this section is to show that the results attained in the theoretical assessment of a proposed ZWS attained in Ndumo can be generalised to other rural areas in South Africa. Thus it will be shown that the zero waste guidelines that will be proposed for Ndumo would tend to apply to other rural areas of similar characteristics. These characteristics are essentially the existing waste management systems or lack thereof, the socio-economic indicators and the institutional set-up existing in rural areas.

7.2.1 Ndumo summary

In Chapter 5, Ndumo was identified as a rural area where a waste management project had been set up by the PEACE Foundation. The waste project was part of a 'poverty alleviation project', which showed that Ndumo was an economically deprived area. This economic status was illustrated by a 97% unemployment rate, with 61% of households having no income. Furthermore, the poverty rate in Ndumo is 69% and the major business in the area is a supermarket. In terms of services, it was shown that 48% of households had no access to clean water, 95% had no access to electricity, 63% had no access to refuse disposal, with 33% disposing their waste in illegal dumps and 77% do not have access to toilets of any type.

Due to the existence of a waste management project, Ndumo was used as a case study for the assessment of an existing waste management project in a rural area. The advantages and problems associated with the project were identified and discussed in Chapter 5. It was also concluded in Section 5.3.5 that the waste management project implemented in Ndumo was environmentally, economically, socially and institutionally unsustainable. Hence there was a need for application of the ZWS in Ndumo.

The waste management project was used as a basis to set-up a proposed ZWS in Ndumo. Due to lack of finances, the proposed ZWS could not be implemented in Ndumo. Theoretical assessment using the sustainability criteria showed that the proposed ZWS would not be sustainable without financial support from the Jozini Municipality or external donor funding. It was also shown that the main constraints to the implementation of the proposed ZWS were the lack of administrative capacity and financial resources within the Jozini Municipality and opposing expectations of the community in terms of its needs assessment.

7.2.2 Characteristics of rural areas

It was shown in Section 3.5.1 that rural areas consist of commercial farms, small settlements, rural villages and other areas further away from towns and cities. It was also shown that rural areas have the following characteristics: 70% of poor people live in rural areas and the poverty rate stands at 70%; 45% of households do not have access to clean water; 62% do not have access to electricity; 26% do not have access to toilets of any type and 85% of roads to rural villages are in adequate. Furthermore, there is a poor delivery of basic services in rural areas, with 73% of households having no waste collection services. This lack of services is due to Municipalities that are understaffed and have little or no tax base to support these services (Republic of South Africa, 2000c). This is despite the fact that delivery of basic services is required of Municipalities as mandated in the Local Government Municipal Systems Act (Republic of South Africa, 2000a). In conclusion, it can be seen that rural areas are characterised by poverty, lack of basic services and institutional arrangements that cannot adequately cope with providing basic services (Republic of South Africa, 2000c).

Comparison of the aforementioned indicators with those of Ndumo shows that Ndumo is typical of a rural area and thus the conclusions reached in the assessment of the proposed ZWS would probably be representative of rural areas. This means that the zero waste guidelines developed for Ndumo would tend to apply to other rural areas as well.

7.2.3 Zero waste guidelines

The key to application of zero waste guidelines to Ndumo is the provision of waste collection services to households. The waste collectors employed in the waste management project should carry out the collection once a week from each household. Collection of waste from the major waste collectors would be done on a scheduled basis. Wet waste would be used for composting, while the recyclables would be sorted and stored at the waste centre. A waste stream analysis would need to be carried out on the waste arising from households and the major waste generators. With the results from the waste stream analysis, transportation schedules and costs can then be worked out for transportation of the recyclables to the Jozini Recycling Centre. Other rural areas within the vicinity of Jozini should also be encouraged to set up similar waste management systems and sell their recyclables to Jozini. Although this will increase the mass of recyclables at the centre, giving the centre leverage when negotiating prices with recyclers, there is a concern with regard to recyclables stockpiled in Jozini and the location of centres willing to buy the recyclables. But given a steady supply of recyclables, contracts could then be entered into with the recyclers. Such contracts would insulate the Jozini Centre from fluctuations in the price of recyclables in the short to medium term.

LCA should be carried out to identify products that could be introduced back into Ndumo and how this would be done. An assessment of the response of householders to the reintroduction of recycled products would also need to be carried out. The results of the assessment would then be used to decide how to run a campaign to maximise the use of such products in Ndumo.

At-source separation of household waste should be encouraged on the part of householders. Educational campaigns would be carried out to communicate why source separation should be done. The predominant language for the campaign should be isiZulu, which should be supplemented by English when required. Once the Jozini Municipality is committed to implementing ZWS, household attitudes towards recycling should be tested by use of questionnaires. The results of the questionnaire would then yield appropriate communication media to use in the educational campaign. This could involve visits to schools in the area, holding demonstrations at community meetings and airing waste programmes over the local radio. The educational drive would be reinforced with demonstrations for at-source separation that could be done by the waste collectors themselves.

Whilst at-source separation for recycling purposes would be introduced and reinforced through demonstrations, waste minimisation behaviour is another area that would require assessment. From the results of such an assessment, communication strategies would then be developed to make the community aware of waste minimisation mechanisms. Emphasis should be placed on waste reduction at point of purchase followed by reuse within the household. But given the scarcity of resources in rural areas, implementing waste minimisation might prove easier than implementing at-source separation for recycling.

It is important to note that educational campaigns to get households involved in the new system would need to take place at the same time that waste collection system is being implemented and made efficient. The educational campaign would have to be also carried out on an ongoing basis. The administrative and financial burden of setting up and maintaining the new waste management system would then be borne by the Jozini Municipality, which should be adequately supported by Provincial Government. In this way, zero waste would be established in Ndumo. It should also be borne in mind that zero waste would have to be applied within the context of poverty alleviation; otherwise it will not succeed in rural areas. The sustainable livelihoods framework, which is beyond the scope of this thesis, can be utilised in this regard. This is the framework that is being used by PEACE in Ndumo.

7.3 Zero waste in urban areas

Similar to rural areas, the aim of this section is to show that the results attained in the theoretical assessment of a proposed ZWS attained in Durban can be generalised to other urban areas in South Africa. Thus it will be shown that the zero waste guidelines that will be proposed for Durban would tend to apply to other urban areas of similar characteristics. These characteristics are essentially the existing waste management systems, the socio-economic indicators and the institutional set-up existing in urban areas.

7.3.1 Durban summary

In Chapter 6, Mariannhill Park and Nazareth were presented as case study areas for the application of a ZWS. It was also stated that 95% of the waste arising from both areas comes from formal housing. And with a minimum of 76% formal housing in both areas, it can be seen that most of the post-consumer waste arising in these areas comes from formal housing. Furthermore, waste collection services extend to most households in both areas as shown in Table 7.1. The other socio-economic and basic services levels are also shown in the table.

Table 7.1: Socio-economic and basic services indicators for Mariannhill Park and Nazareth (eThekwini Municipality, 2007)

Indicators	Mariannhill Park	Nazareth
Households with no income	22%	19%
Economic dependency ratio	4	3
Households with electricity	82%	82%
Formal Housing	77%	88%
Waste collection services	88%	94%
Literacy rate	74%	62%

In terms of post-consumer waste management, it has been shown that Durban has a well developed integrated waste collection and disposal system. Using the case study areas of Mariannhill Park and Nazareth, it was shown the application of the proposed ZWS was possible. It was also shown that despite the difference in income levels, there was a willingness among households in both areas to recycle their waste using at-source separation. However, institutional arrangements were shown to be the main constraint in the application of the proposed ZWS. Although these institutions, the Municipality and DSW in this case, mainly lack capital funding to implement the proposed ZWS, their waste management policy is biased against zero waste in general. Thus lack of funding and negative policy measures will have to be overcome in order for implementation of ZWS to be possible.

7.3.2 Characteristics of urban areas

It was shown in Section 3.5.3 that urban areas have well developed physical infrastructure and can be subdivided into the urban core and urban fringe as discussed in Section 4.3. It was also shown in Section 3.5.3 that urban areas have a poverty rate less than rural areas, only 2% of households have no access to clean water, less than 30% have no access to electricity and that the household adult literacy rate is 96%. Comparison of these figures with Table 7.1 shows that Mariannhill Park and Nazareth are typical urban areas. Furthermore, both areas can be considered part of the urban core as waste collection service coverage is more than 88%. This percentage is higher than that given for kerbside collection in urban areas as illustrated in Table 3.1. Thus it can be established that Mariannhill Park and Nazareth are typical of urban areas in South Africa, though it has to be taken into account that these areas represent low and middle income households as was established in Section 6.5.2. Therefore, it can be taken that the zero waste guidelines developed for Mariannhill Park and Nazareth will tend to apply to other urban areas with similar socio-economic profiles.

7.3.3 Zero waste guidelines

Waste collection services in the Durban area are well established. What needs to be established in the drive towards zero waste is instilling waste minimisation and recycling behaviour among residents. Since attitudes towards waste minimisation and recycling behaviour are underpinned by different features, appropriate plans would need to be developed to address each type of behaviour.

Waste Minimisation

Studies addressing household behaviour towards waste minimisation should be carried out. The response of householders from such studies would yield the appropriate levels for waste minimisation behaviour. Educational campaigns can be designed to encourage and instill waste minimisation behaviour among households. The goal of such campaigns is to get householders to minimise waste at point of purchase and through re-use within the home. Even though the principles of waste minimisation are the same, educational campaigns should be designed to suit the needs of each community. Thus educational campaigns should be run using appropriate languages in Mariannhill Park and Nazareth. Also, the medium of communication used should be as determined from social assessment. The use of questionnaires has been found to be appropriate in this regard, though the use of other social analysis tools is not discouraged.

Recycling

Where level of service in terms of waste collection and disposal are high, there is a willingness to recycle by householders. This willingness to recycle should be used as motivation to set up recycling schemes that utilise at-source separation within households. Educational campaigns would then need to be run to encourage maximum participation of householders in recycling schemes. Householders would then be given a choice of which type of collection system they want to participate in. This could either be kerbside, dropping of recyclables at recycling centres or using special collection points such as those provided in shopping malls. The availability of the different options should be advertised in the local media. Incentives to encourage householders to participate in recycling would need to be identified and implemented appropriately.

Educational campaigns to start at-source separation should be designed. These should be coupled with ongoing campaigns to motivate householders to continue with at-source separation after the initial start up campaign. Medium of communication and language used in the campaigns should be appropriate for the community being served. Barriers to at-source separation would need to be identified and addressed in the educational campaigns. Addressing these barriers would encourage the maximum number of households to participate in recycling. Some of the possible barriers to recycling have been discussed in Section 2.4.3.

Recyclers have already been defined for a composite recycling scheme for Mariannhill Park and Nazareth (see Section 6.4.4). What needs to be investigated though is the possibility of reintroducing the recycled products into Durban. The response of householders to buying such products would need to be assessed. The results of the assessment can then be used to decide how to run a campaign to maximise the use of such products in Durban.

7.4 Zero waste in South Africa

The guidelines developed in the Sections 7.2.3 and 7.3.2 are summarised in this section. As highlighted throughout this thesis, these guidelines are for post-consumer waste and are produced specifically for the management of four recyclable materials contained in post-consumer waste: paper, cans, glass and plastics. Pre-consumer waste is not covered in terms of the scope of this research. It would suffice to state that guidelines for pre-consumer waste would form around the development of clean design and clean production technologies, waste minimisation clubs and designing products that could be reused, repaired and recycled. This involves a shift from unsustainable (cradle to grave) production processes, to sustainable (cradle to cradle) production processes. However, such a shift cannot take place without government intervention through policies that encourage zero waste. Government must raise demand for reusable, remanufactured and sustainably recycled products; levy environmental taxation on bad packaging and product design; implement education and assistance programmes; and support the development of waste avoidance, reduction, minimisation, sorting, recovery, reuse, repair, remanufacture, sustainable recycling and facilities required in each process (Earthlife Africa, undated).

Having developed and implemented zero waste guidelines at pre-consumer level will make it easier to implement zero waste guidelines for post consumer waste. The type of consumer products produced using these guidelines will facilitate reuse, repair and recycling. And the amount of waste needing disposal will be reduced due to the application of higher levels of the waste hierarchy as shown in Figure 2.2.

7.4.1 Summary of zero waste principles

The principles underpinning zero waste have already been discussed in Section 2.5.2. and can be summarised as follows:

- Promoting waste minimisation at source and point of purchase

- Promoting repair, resale and reuse of durable products made from fewer material types and designed to be recycled when they outlive their usefulness
- Investing in resource recovery facilities that enable materials discarded by the community to be reused, recycled and remanufactured
- Encouraging the use of recycled content products by manufactures by providing economic incentives to make such processes viable

The general application of these principles to post-consumer waste arising from both rural and urban areas will be discussed in the next section.

7.4.2 General guidelines for zero waste

At the core of waste management in any area is the provision of waste collection services. In this way, waste arising from that area can enter the formal waste stream. This reduces littering and the waste generated can then be managed properly. In rural areas, collection can be carried out by subcontractors residing in those areas. In that way, the burden of unemployment may also be reduced in those areas. Urban areas will still follow the waste collection methods identified in Chapter 6. Maximising the efficiency of the waste collection systems will make implementation of zero waste guidelines easier, as an efficient system will motivate households to participate in zero waste. These guidelines are divided into waste minimisation and recycling, since zero waste in not reliant purely on recycling (Earthlife Africa, undated), but on a systematic application of the waste hierarchy.

Waste Minimisation

This forms the first part of a two step process of achieving zero waste in post-consumer waste. Fundamental to waste minimisation are the attitudes of the waste generators. Barr et al. (2004) hypothesise that waste minimisation behaviour is more likely to be driven by concern about environmental issues and concern for community. But this is for developed countries. In contrast, the factors driving waste minimisation in developing countries are undetermined, and the results from the research documented in this thesis are inconclusive. But as discussed in Chapter 2, waste minimisation is a key technique in reducing the amount of waste needing disposal. Hence households will need to be educated about different waste minimisation practices that they can undertake. The main goal of this process is to get the households to reduce their waste at the point of purchase. This reduction involves households buying in bulk, which generates less packaging waste than buying the same amount of material in smaller amounts. An example can be purchasing cool-drink in a 2 Litre PET bottle rather than in a six-pack of cans.

Waste minimisation at point of purchase also involves choosing recyclable packaging over non-recyclable packaging. This is the attitude that would need to be reinforced in the short term. With changes in product design in the long term, this issue should no longer apply. Also, waste minimisation at point of purchase would involve choosing products that can be reused at home. The greater the number of alternative uses for the product, the better the product is. Choosing long-life products is another way of minimising waste at point of purchase. In this way, waste minimisation not only reduces the amount of waste that is generated, it also reduces complications downstream when the product reaches its end-use within the home. Then recycling, rather than disposal, would be the next step in the life cycle of the product.

Recycling

Recycling forms the other part of zero waste. Here, products that have reached their end use within the home are reintroduced into the manufacturing process to form new products. For cans and glass, closed loop recycling would be appropriate since these materials can be recycled indefinitely. Paper and plastics would need to employ both open loop and closed loop recycling, given that they cannot be recycled indefinitely. The starting point of recycling is in the home.

As with waste minimisation, the determinants of recycling attitudes of households will need to be established. Reinforcement of these attitudes through educational campaigns then needs to take place. This can be either through events, the media or special days. It can also take place through planned programmes being run at schools, institutions and companies. The main goal of this process would be to get the maximum number of households participating in recycling schemes.

The next step would then be to educate households on how to separate their waste at-source. This involves the use of a wet/dry model. In this model, putriscibles (wet waste) are stored in one bag, whereas the recyclables (dry waste) are stored in another bag. The advantages of using this type of model have been discussed in Section 6.3.2. These bags can be collected separately on the same day. Collection methods identified in Section 6.3.2

can be used. The wet waste can be transported to composting plants while the recyclables can be transported to materials recovery facilities (MRFs). For wet waste that cannot be used to make compost, treatment methods would need to be applied to the waste to make it environmentally safe to dispose in landfills. At the MRFs, the recyclables would then be separated, sorted and baled. Processing of the recyclables would be done manually. This enhances the social aspects of recycling in terms of job creation. The baled recyclables would then be stored in skips awaiting collection by recyclers/converters.

As discussed in Section 2.4.3, markets will have to be created for the recycled products. Here again, education of the public to increase their awareness of buying recycled products is important. Legislation can also be used to create markets for recycled products, although this has drawbacks as discussed in Section 2.4.3.

7.5 Discussion

It has been established in this thesis that one of the main barriers to attaining zero waste is the lack of institutional sustainability. Unless institutional sustainability is accomplished, the zero waste guidelines proposed and discussed in Sections 7.2.3, 7.3.3 and summarised in Section 7.4.2 cannot be implemented. It is important to note that these guidelines are a practical application of the zero waste model developed in chapter 3.

In order to address a lack of institutional sustainability with regards to solid waste management in general, Mega-Tech Inc. (2004) proposed the following set of principles: provision of background information for policy makers; development of regulatory and financial policy framework; development of effective communication, awareness and training programmes and; provision of appropriate infrastructure. Using these principles in light of the needs of the present study, the proposed zero waste guidelines presented in sections 7.2.3, 7.3.3 and 7.4.2 are expanded on to include specific suggestions on how to achieve post-consumer waste institutional sustainability:

1) Information about the volume and source of waste streams should be supplied to policy makers. This information should be of sufficient detail to enable policy makers to make sound decisions about post-consumer waste management issues.
2) Appropriate incentives should be identified in order to ensure that post-consumer waste generators implement waste minimisation and recycling. This will require

municipalities and waste managers to adopt appropriate administrative and financial policy frameworks, which should be based on the duty of care principle.

3) Training programmes should be implemented in order to increase technical capacity amongst policy makers and waste managers. These programmes should include training in effective communication needed to raise awareness among households of the techniques, opportunities and benefits associated with waste minimisation and recycling.
4) Appropriate physical infrastructure, for example, materials recovery facilities and waste collection vehicles, needs to be made available for use in recycling of post-consumer waste. Such infrastructure should be supplemented by household waste storage bins that facilitate at-source separation of recyclables. For examples, bins should be of appropriate size and should at least two compartments for storing household waste.

Application of these suggestions require a radical shift from the current practice of dealing with post-consumer or any type of waste by waste management practitioners. This current practice is essentially the main institutional barrier in attaining zero waste; it is explained by Vorster and Mollekopf (2002) as follows:

> "I am under the impression that that managers of our country's waste facilities are under constant pressure from their local authorities to reduce the cost per ton of waste handled i.e. they should minimise k, where k is given by
>
> k = annual budget / tons of waste handled during the year
>
> Because these managers are, without exception, well schooled in engineering and have a fair grasp of the fundamentals of mathematics, they are quick to rewrite the equation in the form
>
> Annual budget = k x Tons of waste handled during the year
>
> from which it becomes clear that, given that k must be minimised, they can only increase their annual budgets by maximising the amount of waste handled. The overall result of this is that the three R's of waste management (reduce, re-use and

recycle) become nothing more than a nice topic for conferences --- applying it to real life would be financial suicide!" (Vorster and Mollekopf, 2002)

7.6 Summary

In this Chapter, the guidelines for implementing zero waste have been proposed. This proposal fulfils the final objective for this thesis as set-out in Chapter 1. These guidelines were developed from the results of the case studies and are based on the principles and strategies of zero waste discussed in Chapter 2. Waste minimisation, at point of purchase or through reuse, and recycling, with at-source separation, have been identified as the two processes that can be used to achieve zero waste in post-consumer waste. The major assumption made in this chapter is that waste minimisation and recycling form the bulk of achieving zero waste in the short term for the materials identified in Chapter 2. In the long term, it is envisaged that zero waste would be made up entirely of waste minimisation and recycling. This is dependent on zero waste being achieved in product design, with products being designed for multiple use and recyclability at their end of life. Application of these guidelines however, is also dependent on the institutional sustainability of the waste management service providers. Since these waste service providers do not meet institutional sustainability requirements, suggestions have been proposed on how to attain institutional sustainability. As shown by the case studies, this is a long term view of waste management in South Africa. This conclusion will be discussed further in Chapter 8, the overall conclusions chapter.

CHAPTER 8

8. CONCLUSIONS

8.1 Introduction

The purpose of this chapter is to reach conclusions based on the research documented in this thesis. These conclusions are in fulfilment of the objectives that were presented in Chapter 1. A summary of the main contributions of this thesis to knowledge in waste management in South Africa is given in Section 8.2. The main conclusions are presented in Section 8.3, while the overall discussion of the work and the recommendations arising from it are presented in Section 8.4.

8.2 Summary of investigation and contribution to knowledge

In this thesis, the concept of zero waste and its applicability within waste management in the South African context has been investigated. This has been done by reviewing existing literature and using it to propose zero waste schemes for implementation in rural and urban case studies. The ZWS has been formulated for the recyclable fractions arising in typical post-consumer waste. These recyclables are paper, cans, glass and plastics. Life cycle assessment has shown that closed loop recycling can achieve zero waste for cans and glass, while open loop recycling is appropriate for paper and plastics.

The applicability of ZWS, for these recyclables, in the case study areas has been assessed using four sustainability criteria: environmental, economical, social and institutional. Although the proposed ZWS could not be implemented practically, results from the assessment show that there is a possibility for application of the ZWS to rural and urban areas. Based on the results of the investigation, institutional arrangements have been identified as the main constraints in the applicability of ZWS. Suggestions have been proposed in order to deal with this lack of institutional sustainability in post-consumer waste. In addition, zero waste guidelines have been proposed for application to rural and urban areas as and when the problems related to institutional sustainability have been addressed. The significant contributions of this thesis to knowledge in waste management in South Africa are summarised below.

- A conceptual zero waste model for application to post-consumer waste in South Africa has been proposed. The development of the ZWM was important given that it had been shown in the literature review that such a model does not exist for post-consumer waste management in South Africa. The model incorporates both waste minimisation and recycling, and seeks to reduce the amount of waste currently being generated by households. This reduction in waste is in line with the goals of the Polokwane Declaration, and ultimately, the goal of achieving sustainable development of waste management systems.

- The applicability of the zero waste concept has been tested within the South African context using both rural and urban case studies. This is a departure from current research on waste management in South Africa as such research usually considers rural and urban areas separately, and hardly ever considers them together within the same frame of reference. Furthermore, the inclusion of rural areas in this research has highlighted the importance of proper waste management services in rural areas. At present, these services are being provided on an ad-hoc basis given that the municipalities responsible for these areas do not have the necessary administrative and financial capacity to support the provision of such services. Lack of proper waste management services means that zero waste will probably not be realised in rural areas in the near future.

- It has been shown that the main constraint to attaining zero waste and promoting sustainable development, albeit for a limited range of post-consumer recyclable fractions, is the institutional arrangements within municipalities that are responsible for waste management services. It has been shown that municipalities lack the administrative capacity and financial resources to implement zero waste. As it happens, these municipalities are pressed to provide basic waste collection and disposal services to an ever increasing clientele. In addition, it has been shown that the policies adopted by some urban municipalities do not favour application of waste minimisation and recycling to post-consumer waste, and ultimately zero waste. Suggestions have been made to overcome this barrier of institutional unsustainability, but it seems that their application will be put off for some time. This appears to be due to the lack of political will to implement such changes.

- An attempt has been made to provide environmental, economic and social costs and benefits associated with the implementation of recycling initiatives to post-consumer waste. These costs and benefits have been identified using an appropriate mix of multi-criteria models which include landfill space saving, cost benefit analysis and the use of questionnaires in social assessment. While these models could be considered standard procedure in sustainability assessment of waste management issues, the addition of the institutional analysis and development framework for institutional assessment has broadened the scope of the overall sustainability considerations. In fact, the spectrum covered by IAD Framework in institutional assessment has identified other factors, apart from administrative capacity and economic efficiency, which make it difficult for municipalities to implement sustainability principles in the management of post-consumer waste. These factors are equity, accountability and adaptability.

The contributions presented in this section are a summary of the conclusions reached for the research documented in this thesis. These conclusions will be presented in the next section.

8.3 Main conclusions

8.3.1 Zero waste model

A conceptual zero waste model has been developed for application to post-consumer waste management in rural and urban areas. Waste minimisation through source reduction and reuse, and recycling, using at-source separation or a wet/dry model, have been identified as key strategies for application of the ZWM in rural and urban households. The ZWM is based on achieving sustainability in waste management systems and the sustainability dimensions considered in it are environmental, economic, social and institutional. These dimensions are employed with the aim of achieving the higher level goals of the waste hierarchy. It should be understood that the ZWM was developed for the recyclable fraction of post-consumer waste and did not consider either the putriscible fraction of post-consumer waste or pre-consumer waste. This is the limitation of this model. However, it should be noted that application of cradle to cradle principles in the production of consumer goods will enhance the applicability of the ZWM to post-consumer waste.

8.3.2 Zero waste in rural areas

The Ndumo community has been used as a case study for the application of a proposed ZWS in rural areas. The results of the existing waste management project have shown that waste management services are either lacking or non-existent in rural areas. Furthermore, where such services are being provided, application of the sustainability criteria has shown that those services are unsustainable. This unsustainability is mainly due to the fact that the Municipalities responsible for these areas lack the administrative capacity and financial resources to implement waste collection and disposal systems. An assessment of the proposed ZWS, which is based on sustainability criteria, has shown that zero waste could be achieved in rural areas if households are involved in the proposed ZWS. In addition, waste minimisation has been identified as being more important than recycling given the considerable distance through which recyclables would have to be transported to reach recycling markets. Institutional arrangements have been shown to be the main constraint in the application of zero waste in rural areas as is the case for existing waste collection services. These institutional arrangements are the primary reason that a pilot zero waste Scheme could not be practically applied in the case study area. Another major constraint to application of zero waste is the primary needs of the communities involved, given the socio-economic conditions existing in rural areas. The community was shown to assign a low priority to the provision of waste management services, let alone zero waste. Hence it can be concluded that zero waste, as defined in the Polokwane Declaration, is a long way off in rural areas of South Africa.

8.2.3 Zero waste in urban areas

The communities of Mariannhill Park and Nazareth have been used as a case study for the introduction of a proposed ZWS into an already existing integrated waste management system. The proposed ZWS is based on a ZWM developed for post-consumer waste. An assessment of the proposed ZWS based on the sustainability criteria has shown zero waste could be achieved in the case study areas. The benefits of the application of the proposed ZWS would include savings in landfill space and environmental awareness on the part of households. Results from the environmental assessment show that landfill lifespan could be increased by a very significant 30 – 200% with the application of at-source separation for recycling. A cost benefit analysis conducted for the proposed ZWS showed that the scheme would be economically beneficial. The CBA results showed that cost saving would be between R199/m^3 and R518/m^3 in the high profit scenario and R79/m^3 –

$R225/m^3$ in the low profit scenario. The social assessment indicated that at-least 74% of households would be willing to source separate their waste and the recyclables capture rate would be at-least 84%. Despite these positive results, the institutional assessment showed that the institutions responsible for waste management in the case study areas did not have the financial resources to implement the proposed zero waste schemes. Moreover, current policies being implemented by municipalities were clearly not in favour of the application of zero waste. The time required for change in these policies and availability of funding for pilot scale application of the ZWS cannot be determined at present. Hence it can be seen that application of zero waste in urban areas, as defined in the Polokwane Declaration, is still some way off. This conclusion applies mainly to urban areas that have the same socio-economic indicators as the case study areas.

8.3.4 Zero waste guidelines

The concept of zero waste with regards to post-consumer waste has been investigated. The components underpinning zero waste have been discussed, as well as the strategies that could be adopted in the move towards zero waste. Within waste management in South Africa, waste minimisation and recycling have been identified as key strategies in the move towards zero waste. Waste minimisation at point of purchase and through reuse of products within the home will reduce the amount of waste generated by households. At-source separation or a wet/dry model has been identified as a strategy needed to maximise recycling of the waste generated after waste minimisation has been applied. Using each strategy on a stand alone basis in the move to achieve zero waste will not be as effective as using both concurrently.

Finally, the results from the case studies suggest that application of zero waste in South Africa is still a long way off. To achieve zero waste in rural areas requires the introduction of integrated waste management systems and then application of waste minimisation and recycling in such systems. These initial steps need to be carried out first before the ZWM can be applied. The situation in urban areas is better given that integrated waste management systems are already in place. The ZWM can then be applied to such systems in the move towards zero waste. In both cases however, institutional constraints will have to be overcome. There is uncertainty as to when or how these constraints can be overcome, which then leads to the conclusion that application of zero waste in post-consumer waste in South Africa is unlikely to occur in the near future without strong political support.

8.4 Discussion and Recommendations

As outlined in Chapter 1, the research documented in this thesis is an attempt to assess the possibility of attaining sustainable development in post-consumer waste management in South Africa. This possibility has been investigating by applying a zero waste model to waste management systems in rural and urban areas. An assessment of the zero waste schemes developed from the ZWM has been made based on the sustainability criteria. The theoretical results obtained have shown that the ZWS would be sustainable if the existing institutional arrangements could be transformed. However this research is only focused on a few materials within the post-consumer waste stream. The focus on a few materials and the theoretical nature of the research are some of the limitations of this research. The limitation of the theoretical nature of the results could be eliminated by an actual implementation of the proposed ZWS. However, this is not possible at present due to the lack of institutional arrangements within Municipalities to implement the zero waste schemes.

Research into the possible arrangements that could be applied within Municipalities to solve institutional unsustainability should be carried out as an extension of the research presented in this thesis. This research is important because as shown in this thesis, existing institutional arrangements are the main constraints to implementing the proposed ZWS. Other possible extensions, which include the number of material types earmarked for recycling, should focus on refining the ZWS already proposed. These refinements should include: updating the waste stream analysis data for urban municipalities and conducting waste stream analysis in rural areas where possible; updating the transportation costs for recycling in rural areas; applying transportation models to waste collection systems in urban areas to see the impact of implementing ZWS and optimising such models within environmental and economic constraints; investigating the possible social analysis models for use in rural areas; and carrying out probabilistic social analysis in high income urban areas for incorporation into proposed ZWS for urban areas.

APPENDIX

A1: Extract of Skills Training Programme for Waste Workers in Ndumo (Sourced from www.ecosystems.co.za)

Training Courses Offered

The courses listed below are conducted over a six week period. In this time students are exposed to all aspects of agriculture and conservation opportunities. Only then so they select the activity which they will pursue. All courses also include life skills, business skills and communication skills. On successfully completing the training the student will receive a Technikon of Natal attendance certificate, which will have an academic value of thirty (30) credits, which can then be used to acquire a NQF certificate once they acquire one hundred and twenty (120) credits.

We are presently applying for accreditation with the Primary Agricultural Seta (PAETA). Entrance levels can be from illiterate stage, NQF 2 (grade 9) to NQF 5 (grade 12). Students could eventually develop from grade nine to Matric doing agricultural subjects.

1. **Sustainable Food production**

- Organic Agriculture;
- Permaculture;
- Organic Hydroponics;
- Water Harvesting and Conservation;
- Sustainable Livestock Production;
- Sustainable Bee Keeping;
- Fish Farming;
- Traditional Plant and Muthi Production;
- Community Nursery Establishment & Propagation;
- Broiler Production;
- Free Range Egg Production (using traditional fowls);
- Guinea Fowl Production;
- Sustainable Irrigation;
- Alternative Energy Sources.

2. Health

- Food Processing;
- Traditional Plant and Muthi Production and uses;
- Food Processing and Preserving.

3. Skills

- Basic Business Skills;
- Basic Book Keeping;
- Basic Office Administration.

4. Waste Management

- Integrated Waste Management;
- Waste as a Business Opportunity;
- Integrating Waste Into Food Production;
- Alternative Uses for Waste;
- Crafts from Waste.

5. Micro Enterprises

- Block Making;
- Rustic Furniture and Jungle Gym Production.

6. Horticulture

- Garden Maintenance;
- Alien Weed Eradication and Management;
- Safe Use of Chemicals.

7. Forestry

- Harvesting;
- Siviculture Practices;
- Safe Use of Chemicals;
- Safety At the Work Place.

8. Mechanical

- Chain Saw Operator;
- Advanced Arborist Training;
- Brush Cutter Operator;
- Lawn Mower Operator;
- Small Plant Repairs and Maintenance.

9. Crafts

- Crafts From Waste;
- Grass Blind Making Using a Loom;
- Bone/Horn and Soap Stone Carving.

10. Ecotourism

- Lodge Management;
- Lodge Maintenance;
- Field Guide Development.

A.2 Calculation for Transportation Costs (Ndumo to Jozini)

Statistics used sourced from (www.tansport.gov.za/library/index.html)

Part 2: Statistics

2.0 Road Transport

2.3 Vehicle Statistics (Tables 2.3.6 – 2.3.8)

Assumptions

- Vehicle Costs are at 2001 prices
- Prices used for Fixed Costs
  - Upper limit: New Vehicles
  - Lower Limit: Used Vehicles
- Type of Car: Pick up (Bakkie) hauling a trailer
- Distance Travelled
  - Assume 20,000km/year overall for vehicle
  - Number of trips to Jozini – 12 per year
  - Ndumo to Jozini – 140km roundtrip

Calculations

A.2.1 New Vehicle (Upper limit)

1. Fixed costs
   - Take commercial Vehicle (Table 2.3.6)

     Average price = R96,929
   - Total distance travelled taken as 20,000km/year (Table 2.3.8)

     Therefore, Estimated Average Fixed Costs = R1,81/km

2. Estimated vehicle operating costs (VOC)
   - Take fuel cost @ R5,50/litre
   - Assume

     Fuel usage of 10litres/100km

     Other costs – 70% of fuel costs

     Factor costs by 1,2 for use of trailer

- Fuel cost = R5,50/l * 10l/100km = R0,55/km
- Vehicle operating Costs = (R0,55/km + (0,7 * R0,55/km)) * 1,2 = R1,12/km

3. Total User Costs = Fixed Costs + VOC
   = R1,81 /km + R1,12/km
   = R2,93/km

- Cost per trip = R2,93/km * 140km = R410,00
- Cost per year = R410 * 12 = R4920,00

A.2.1 Used Vehicle (Lower limit)

1. Fixed costs
   - Take commercial Vehicle (Table 2.3.6)
     Average price = R53,571
   - Total distance travelled taken as 20,000km/year (Table 2.3.8)

     Therefore, Estimated Average Fixed Costs = R1,00/km

2. Estimated vehicle operating costs (VOC)
   - Take fuel cost @ R5,50/litre
   - Assume
     Fuel usage of 13litres/100km
     Other costs – 70% of fuel costs
     Factor costs by 1,2 for use of trailer
   - Fuel cost = R5,50/l * 13l/100km = R0,72/km
   - Vehicle operating Costs = (R0,72/km + (0,7 * R0,72/km)) * 1,2 = R1,47/km

3. Total User Costs = Fixed Costs + VOC
   = R1,00 /km + R1,47/km
   = R2,47/km

- Cost per trip = R2,47/km * 140km = R346,00
- Cost per year = R346 * 12 = R4152,00

B.1 Typical Recycling Costs for Recyclable Materials

Table of typical direct costs incurred to send cardboard to the paper mill (Source: Beningfield, 2002)

Direct Costs	Rates
Generator	
- Desk Bins	R 5.00 per bin
- Wheeli-bins	R 340.00 per bin
- Labour to load cardboard into the compactor	R 17.50 per ton
@R7.00 / hr ; 400 kg/hr	
Collector	
- Transport in 9 ton vehicle within 50 km radius	R 97.22 per ton; ROPO
- Payment to generator	R 250.00 per ton
- Static Compaction Unit	R 40.00 per ton
Processor	
- Transport in super-link vehicle: RFA rate	R 0.37 per ton per km
- Large baler @ R3 million	R 48 400.00 per month

Table of typical direct costs incurred to send PET to the end-user (Source: Beningfield, 2002)

Direct Costs	Rates
Generator	
- Labour to separate PET	R 70.00 per ton
@R7.00 / hr ; 100 kg/hr	
Collector	
- Transport in 7 ton vehicle within 50 km radius	R 750.00 per ton
- DE-cap & De-label, manual labour	R 350.00 (Coca-Cola) & R 860.00 (Water) per ton
- Granulate	R 110.00 – R 1000.00 per ton
- Wash	R 500.00 per ton

Table of typical direct costs incurred to send cans to the processor (Source: Beningfield, 2002)

Direct Costs	**Rates**
Generator	
- Labour to separate PET	R 70.00 per ton
@R7.00 / hr ; 100 kg/hr	
Collector	
- Transport in 7 ton vehicle within 50 km radius: Steel cans	R 330.00 per ton
Aluminium cans	R 620.00 per ton
- Bulk bags	R 34.00 each; 3-6 months
- Steel Frame	R 1500.00

B.2 Urban Case Study – Environmental Data

B.2.1 Mariannhill Park

Table B.2.1.1: Disposal costs and Landfill space utilisation for Mariannhill Park in 2003

		Disposal Costs (R)			Landfill Space (m^3)		
	Mass of Waste (kg)	Residual	Scenario 1a	Scenario 2	Residual	Scenario 1a	Scenario 2
		0.11	0.11	0.11	0.00083	0.00083	0.00083
January	87734	9651	4536	6756	73	34	51
February	64127	7054	3315	4938	53	25	37
March	74440	8188	3849	5732	62	29	43
April	73062	8037	3777	5626	61	29	43
May	75384	8292	3897	5805	63	30	44
June	69197	7612	3577	5328	58	27	40
July	77811	8559	4023	5991	65	30	45
August	71107	7822	3676	5475	59	28	41
September	80005	8801	4136	6160	67	31	47
October	84768	9324	4383	6527	71	33	49
November	72658	7992	3756	5595	61	28	42
December	91509	10066	4731	7046	76	36	53
Total	**921802**	**101398**	**47657**	**70979**	**768**	**361**	**538**

Table B.2.1.2: Disposal costs and Landfill space utilisation for Mariannhill Park in 2004

		Disposal Costs (R)			Landfill Space (m^3)		
	Mass of Waste (kg)	Residual	Scenario 1a	Scenario 2	Residual	Scenario 1a	Scenario 2
		0.11	0.11	0.11	0.00083	0.00083	0.00083
January	82799	9108	4281	6376	69	32	48
February	77376	8511	4000	5958	64	30	45
March	84559	9301	4372	6511	70	33	49
April	72073	7928	3726	5550	60	28	42
May	75032	8254	3879	5777	63	29	44
June	74875	8236	3871	5765	62	29	44
July	68651	7552	3549	5286	57	27	40
August	84401	9284	4364	6499	70	33	49
September	89068	9797	4605	6858	74	35	52
October	85023	9353	4396	6547	71	33	50
November	92146	10136	4764	7095	77	36	54
December	107799	11858	5573	8301	90	42	63
Total	**993802**	**109318**	**51380**	**76523**	**828**	**389**	**580**

Table B.2.1.3: Disposal costs and Landfill space utilisation for Mariannhill Park in 2003					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 1b	Residual	Scenario 1b
		0.11	0.11	0.00083	0.00083
January	87734	9651	6471	73	49
February	64127	7054	4730	53	36
March	74440	8188	5491	62	42
April	73062	8037	5389	61	41
May	75384	8292	5560	63	42
June	69197	7612	5104	58	39
July	77811	8559	5739	65	43
August	71107	7822	5245	59	40
September	80005	8801	5901	67	45
October	84768	9324	6253	71	47
November	72658	7992	5359	61	41
December	91509	10066	6750	76	51
Total	**921802**	**101398**	**67993**	**768**	**515**

Table B.2.1.4: Disposal costs and Landfill space utilisation for Mariannhill Park in 2004					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 1b	Residual	Scenario 1b
		0.11	0.11	0.00083	0.00083
January	82799	9108	6107	69	46
February	77376	8511	5707	64	43
March	84559	9301	6237	70	47
April	72073	7928	5316	60	40
May	75032	8254	5534	63	42
June	74875	8236	5523	62	42
July	68651	7552	5064	57	38
August	84401	9284	6225	70	47
September	89068	9797	6570	74	50
October	85023	9353	6271	71	48
November	92146	10136	6797	77	51
December	107799	11858	7951	90	60
Total	**993802**	**109318**	**73304**	**828**	**555**

Table B.2.1.5: Disposal costs and Landfill space utilisation for Mariannhill Park in 2003					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 3	Residual	Scenario 3
		0.11	0.11	0.00083	0.00083
January	87734	9651	7354	73	56
February	64127	7054	5375	53	41
March	74440	8188	6240	62	47
April	73062	8037	6124	61	46
May	75384	8292	6319	63	48
June	69197	7612	5800	58	44
July	77811	8559	6522	65	49
August	71107	7822	5960	59	45
September	80005	8801	6706	67	51
October	84768	9324	7105	71	54
November	72658	7992	6090	61	46
December	91509	10066	7670	76	58
Total	**921802**	**101398**	**77265**	**768**	**585**

Table B.2.1.6: Disposal costs and Landfill space utilisation for Mariannhill Park in 2004					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 3	Residual	Scenario 3
		0.11	0.11	0.00083	0.00083
January	82799	9108	6940	69	53
February	77376	8511	6486	64	49
March	84559	9301	7088	70	54
April	72073	7928	6041	60	46
May	75032	8254	6289	63	48
June	74875	8236	6276	62	48
July	68651	7552	5754	57	44
August	84401	9284	7074	70	54
September	89068	9797	7466	74	57
October	85023	9353	7127	71	54
November	92146	10136	7724	77	59
December	107799	11858	9036	90	68
Total	**993802**	**109318**	**83300**	**828**	**631**

B.2.2 Nazareth

Table B.2.2.1: Disposal costs and Landfill space utilisation for Nazareth in 2003

	Mass of Waste (kg)	Disposal Costs (R) Residual	Scenario 1a	Scenario 2	Landfill Space (m^3) Residual	Scenario 1a	Scenario 2
		0.11	0.11	0.11	0.00083	0.00083	0.00083
January	21700	2387	740	1671	18	6	13
February	18420	2026	628	1418	15	5	11
March	16380	1802	559	1261	14	4	10
April	25920	2851	884	1996	22	7	15
May	17380	1912	593	1338	14	4	10
June	17780	1956	606	1369	15	5	10
July	20520	2257	700	1580	17	5	12
August	17300	1903	590	1332	14	4	10
September	20540	2259	700	1582	17	5	12
October	25640	2820	874	1974	21	7	15
November	21600	2376	737	1663	18	6	13
December	31460	3461	1073	2422	26	8	18
Total	**254640**	**28010**	**8683**	**19607**	**212**	**66**	**149**

Table B.2.2.2: Disposal costs and Landfill space utilisation for Nazareth in 2004

	Mass of Waste (kg)	Disposal Costs (R) Residual	Scenario 1a	Scenario 2	Landfill Space (m^3) Residual	Scenario 1a	Scenario 2
		0.11	0.11	0.11	0.00083	0.00083	0.00083
January	11820	1300	403	910	10	3	7
February	19920	2191	679	1534	17	5	12
March	24420	2686	833	1880	20	6	14
April	22120	2433	754	1703	18	6	13
May	21120	2323	720	1626	18	5	12
June	20520	2257	700	1580	17	5	12
July	20260	2229	691	1560	17	5	12
August	23340	2567	796	1797	19	6	14
September	21520	2367	734	1657	18	6	13
October	23380	2572	797	1800	19	6	14
November	19780	2176	674	1523	16	5	12
December	26740	2941	912	2059	22	7	16
Total	**254940**	**28043**	**8693**	**19630**	**212**	**66**	**149**

Table B.2.2.3: Disposal costs and Landfill space utilisation for Nazareth in 2003					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 1b	Residual	Scenario 1b
		0.11	0.11	0.00083	0.00083
January	21700	2387	1365	18	10
February	18420	2026	1159	15	9
March	16380	1802	1030	14	8
April	25920	2851	1630	22	12
May	17380	1912	1093	14	8
June	17780	1956	1118	15	8
July	20520	2257	1291	17	10
August	17300	1903	1088	14	8
September	20540	2259	1292	17	10
October	25640	2820	1613	21	12
November	21600	2376	1359	18	10
December	31460	3461	1979	26	15
Total	**254640**	**28010**	**16018**	**212**	**121**

Table B.2.2.4: Disposal costs and Landfill space utilisation for Nazareth in 2004					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 1b	Residual	Scenario 1b
		0.11	0.11	0.00083	0.00083
January	11820	1300	744	10	6
February	19920	2191	1253	17	9
March	24420	2686	1536	20	12
April	22120	2433	1391	18	11
May	21120	2323	1329	18	10
June	20520	2257	1291	17	10
July	20260	2229	1274	17	10
August	23340	2567	1468	19	11
September	21520	2367	1354	18	10
October	23380	2572	1471	19	11
November	19780	2176	1244	16	9
December	26740	2941	1682	22	13
Total	**254940**	**28043**	**16037**	**212**	**121**

Table B.2.2.5: Disposal costs and Landfill space utilisation for Nazareth in 2003					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 3	Residual	Scenario 3
		0.11	0.11	0.00083	0.00083
January	21700	2387	1819	18	14
February	18420	2026	1544	15	12
March	16380	1802	1373	14	10
April	25920	2851	2173	22	16
May	17380	1912	1457	14	11
June	17780	1956	1490	15	11
July	20520	2257	1720	17	13
August	17300	1903	1450	14	11
September	20540	2259	1722	17	13
October	25640	2820	2149	21	16
November	21600	2376	1811	18	14
December	31460	3461	2637	26	20
Total	**254640**	**28010**	**21344**	**212**	**162**

Table B.2.2.6: Disposal costs and Landfill space utilisation for Nazareth in 2004					
		Disposal Costs (R)		Landfill Space (m^3)	
	Mass of Waste (kg)	Residual	Scenario 3	Residual	Scenario 3
		0.11	0.11	0.00083	0.00083
January	11820	1300	991	10	8
February	19920	2191	1670	17	13
March	24420	2686	2047	20	16
April	22120	2433	1854	18	14
May	21120	2323	1770	18	13
June	20520	2257	1720	17	13
July	20260	2229	1698	17	13
August	23340	2567	1956	19	15
September	21520	2367	1804	18	14
October	23380	2572	1960	19	15
November	19780	2176	1658	16	13
December	26740	2941	2241	22	17
Total	**254940**	**28043**	**21369**	**212**	**162**

B.3 Urban Case Study – Questionnaires

B.3.1 English Version

B.3.2 isiZulu Version

B.4 Urban Case Study – Economic Assessment Tables

B.4.1 Yield of and Income from Recyclables

Table B.4.1.1: Mass (kg) of recyclables for Mariannhill Park in 2003 and Potential income

	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.07	0.17	0.08	0.07	0.05	0.09
January	87734	6141	14915	7019	6141	4387	7896
February	64127	4489	10902	5130	4489	3206	5771
March	74440	5211	12655	5955	5211	3722	6700
April	73062	5114	12421	5845	5114	3653	6576
May	75384	5277	12815	6031	5277	3769	6785
June	69197	4844	11763	5536	4844	3460	6228
July	77811	5447	13228	6225	5447	3891	7003
August	71107	4977	12088	5689	4977	3555	6400
September	80005	5600	13601	6400	5600	4000	7200
October	84768	5934	14411	6781	5934	4238	7629
November	72658	5086	12352	5813	5086	3633	6539
December	91509	6406	15557	7321	6406	4575	8236
Total	**921802**	**64526**	**156706**	**73744**	**64526**	**46090**	**82962**

Table B.4.1.1: (Continued): Mass (kg) of recyclables for Mariannhill Park in 2003 and Potential income

		Revenue - Recyclables	
Scenario 1a	**Scenario 2**	**Scenario 1a**	**Scenario 2**
0.53	**0.30**		
46499	26320	22153	
33987	19238	16192	
39453	22332	18796	
38723	21919	18448	
39954	22615	19034	
36674	20759	17472	
41240	23343	19647	
37687	21332	17955	
42403	24002	20201	
44927	25430	21404	
38509	21797	18346	
48500	27453	23106	
488555	**276541**	**R232755**	

High Profit

Material	Unit Price
Hard - Plastic	0.50
Soft - Plastic	0.60
Glass	0.10
Tin/Alum.	0.35
Cardboard	0.40
Paper	0.70

Table B.4.1.1: (Continued): Mass (kg) of recyclables for Mariannhill Park in 2003 and Potential Income

		Revenue - Recyclables	
Scenario 1a	Scenario 2	Scenario 1a	Scenario 2
0.53	0.30		
46499	26320	17635	
33987	19238	12890	
39453	22332	14962	
38723	21919	14685	
39954	22615	15152	
36674	20759	13909	
41240	23343	15640	
37687	21332	14293	
42403	24002	16081	
44927	25430	17038	
38509	21797	14604	
48500	27453	18393	
488555	**276541**	**R185282**	

Low Profit	
Material	**Unit Price**
Hard - Plastic	0.50
Soft - Plastic	0.60
Glass	0.05
Tin/Alum.	0.35
Cardboard	0.35
Paper	0.20

Table B.4.1.2: Mass (kg) of recyclables for Mariannhill Park in 2004 and Potential income

	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.07	**0.17**	**0.08**	**0.07**	**0.05**	**0.09**
January	82799	5796	14076	6624	5796	4140	7452
February	77376	5416	13154	6190	5416	3869	6964
March	84559	5919	14375	6765	5919	4228	7610
April	72073	5045	12252	5766	5045	3604	6487
May	75032	5252	12755	6003	5252	3752	6753
June	74875	5241	12729	5990	5241	3744	6739
July	68651	4806	11671	5492	4806	3433	6179
August	84401	5908	14348	6752	5908	4220	7596
September	89068	6235	15142	7125	6235	4453	8016
October	85023	5952	14454	6802	5952	4251	7652
November	92146	6450	15665	7372	6450	4607	8293
December	107799	7546	18326	8624	7546	5390	9702
Total	**993802**	**69566**	**168946**	**79504**	**69566**	**49690**	**89442**

Table B.4.1.2: (Continued): Mass (kg) of recyclables for Mariannhill Park in 2004 and Potential income

		Revenue - Recyclables	
Scenario 1a	Scenario 2	Scenario 1a	
0.53	0.30		
43883	24840	28027	
41009	23213	26192	
44816	25368	28623	
38199	21622	24397	
39767	22510	25398	
39684	22463	25345	
36385	20595	23238	
44733	25320	28570	
47206	26720	30150	
45062	25507	28780	
48837	27644	31191	
57133	32340	36490	
526715	**298141**	**R336402**	

High Profit	
Material	**Unit Price**
Hard - Plastic	0.50
Soft - Plastic	1.00
Glass	0.05
Tin/Alum.	0.50
Cardboard	0.45
Paper	0.80

Table B.4.1.2: (Continued): Mass (kg) of recyclables for Mariannhill Park in 2004 and Potential income

		Revenue - Recyclables	
Scenario 1a	Scenario 2	Scenario 1a	Scenario 2
0.53	0.30		
43883	24840	18754	
41009	23213	17526	
44816	25368	19153	
38199	21622	16325	
39767	22510	16995	
39684	22463	16959	
36385	20595	15549	
44733	25320	19117	
47206	26720	20174	
45062	25507	19258	
48837	27644	20871	
57133	32340	24416	
526715	**298141**	**R225096**	

Low Profit	
Material	**Unit Price**
Hard - Plastic	0.50
Soft - Plastic	0.80
Glass	0.05
Tin/Alum.	0.50
Cardboard	0.15
Paper	0.10

Table B.4.1.3: Mass (kg) of recyclables for Nazareth in 2003 and Potential income							
	Mass of Waste	**Hard Plastics**	**Soft plastics**	**Glass**	**Tin/Alu.**	**Cardboard**	**Paper**
		0.06	**0.25**	**0.07**	**0.06**	**0.12**	**0.13**
January	21700	1302	5425	1519	1302	2604	2821
February	18420	1105	4605	1289	1105	2210	2395
March	16380	983	4095	1147	983	1966	2129
April	25920	1555	6480	1814	1555	3110	3370
May	17380	1043	4345	1217	1043	2086	2259
June	17780	1067	4445	1245	1067	2134	2311
July	20520	1231	5130	1436	1231	2462	2668
August	17300	1038	4325	1211	1038	2076	2249
September	20540	1232	5135	1438	1232	2465	2670
October	25640	1538	6410	1795	1538	3077	3333
November	21600	1296	5400	1512	1296	2592	2808
December	31460	1888	7865	2202	1888	3775	4090
Total	**254640**	**15278**	**63660**	**17825**	**15278**	**30557**	**33103**

Table B.4.1.3 (Continued): Mass (kg) of recyclables for Nazareth in 2003 and Potential income			
		Revenue - Recyclables	
Scenario 1a	**Scenario 2**	**Scenario 1a**	**Scenario 2**
0.69	**0.30**		
14973	6510	7530	
12710	5526	6392	
11302	4914	5684	
17885	7776	8994	
11992	5214	6031	
12268	5334	6170	
14159	6156	7120	
11937	5190	6003	
14173	6162	7127	
17692	7692	8897	
14904	6480	7495	
21707	9438	10917	
175702	**76392**	**R88360**	

High Profit	
Material	**Unit Price**
Hard - Plastic	0.50
Soft - Plastic	0.60
Glass	0.10
Tin/Alum.	0.35
Cardboard	0.40
Paper	0.70

Table B.4.1.3 (Continued): Mass (kg) of recyclables for Nazareth in 2003 and Potential income			
		Revenue - Recyclables	
Scenario 1a	Scenario 2	Scenario 1a	Scenario 2
0.69	**0.30**		
14973	6510	5913	
12710	5526	5019	
11302	4914	4464	
17885	7776	7063	
11992	5214	4736	
12268	5334	4845	
14159	6156	5592	
11937	5190	4714	
14173	6162	5597	
17692	7692	6987	
14904	6480	5886	
21707	9438	8573	
175702	**76392**	**R69389**	

Low Profit	
Material	Unit Price
Hard - Plastic	0.50
Soft - Plastic	0.60
Glass	0.05
Tin/Alum.	0.35
Cardboard	0.35
Paper	0.20

Table B.4.1.4: Mass (kg) of recyclables for Nazareth in 2004 and Potential income							
	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.06	**0.25**	**0.07**	**0.06**	**0.12**	**0.13**
January	11820	709	2955	827	709	1418	1537
February	19920	1195	4980	1394	1195	2390	2590
March	24420	1465	6105	1709	1465	2930	3175
April	22120	1327	5530	1548	1327	2654	2876
May	21120	1267	5280	1478	1267	2534	2746
June	20520	1231	5130	1436	1231	2462	2668
July	20260	1216	5065	1418	1216	2431	2634
August	23340	1400	5835	1634	1400	2801	3034
September	21520	1291	5380	1506	1291	2582	2798
October	23380	1403	5845	1637	1403	2806	3039
November	19780	1187	4945	1385	1187	2374	2571
December	26740	1604	6685	1872	1604	3209	3476
Total	254940	15296	63735	17846	15296	30593	33142

Table B.4.1.4 (Continued): Mass (kg) of recyclables for Nazareth in 2004 and Potential income

		Revenue - Recyclables	
Scenario 1a	**Scenario 2**	**Scenario 1a**	**Scenario 2**
0.69	**0.30**		
8156	3546	5573	
13745	5976	9392	
16850	7326	11514	
15263	6636	10430	
14573	6336	9958	
14159	6156	9675	
13979	6078	9553	
16105	7002	11005	
14849	6456	10147	
16132	7014	11024	
13648	5934	9326	
18451	8022	12608	
175909	**76482**	**R120204**	

High Profit

Material	Unit Price
Hard - Plastic	0.50
Soft - Plastic	1.00
Glass	0.05
Tin/Alum.	0.50
Cardboard	0.45
Paper	0.80

Table B.4.1.4 (Continued): Mass (kg) of recyclables for Nazareth in 2004 and Potential income

		Revenue - Recyclables	
Scenario 1a	**Scenario 2**	**Scenario 1a**	**Scenario 2**
0.69	**0.30**		
8156	3546	3481	
13745	5976	5866	
16850	7326	7192	
15263	6636	6514	
14573	6336	6220	
14159	6156	6043	
13979	6078	5967	
16105	7002	6874	
14849	6456	6338	
16132	7014	6885	
13648	5934	5825	
18451	8022	7875	
175909	**76482**	**R75080**	

Low Profit

Material	Unit Price
Hard - Plastic	0.50
Soft - Plastic	0.80
Glass	0.05
Tin/Alum.	0.50
Cardboard	0.15
Paper	0.10

Table B.4.1.5: Mass (kg) of recyclables for Mariannhill Park in 2003 and Potential income							
	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.043512	**0.105672**	**0.049728**	**0.043512**	**0.03108**	**0.055944**
January	87734	3817	9271	4363	3817	2727	4908
February	64127	2790	6776	3189	2790	1993	3588
March	74440	3239	7866	3702	3239	2314	4164
April	73062	3179	7721	3633	3179	2271	4087
May	75384	3280	7966	3749	3280	2343	4217
June	69197	3011	7312	3441	3011	2151	3871
July	77811	3386	8222	3869	3386	2418	4353
August	71107	3094	7514	3536	3094	2210	3978
September	80005	3481	8454	3978	3481	2487	4476
October	84768	3688	8958	4215	3688	2635	4742
November	72658	3161	7678	3613	3161	2258	4065
December	91509	3982	9670	4551	3982	2844	5119
Total	**921802**	**40109**	**97409**	**45839**	**40109**	**28650**	**51569**

Table B.4.1.5 (Continued)			
Scenario 1b	**Income**	**High Profit**	
0.329448		**Material**	**Unit Price**
28904	13770		
21127	10065	Hard - Plastic	0.50
24524	11684	Soft - Plastic	0.60
24070	11467	Glass	0.10
24835	11832	Tin/Alum.	0.35
22797	10861	Cardboard	0.40
25635	12213	Paper	0.70
23426	11161		
26357	12557		
27927	13305		
23937	11404		
30147	14363		
303686	**R144681**		

Table B.4.1.5 (Continued)			
Scenario 1b	**Income**	**Low Profit**	
0.329448		**Material**	**Unit Price**
28904	10962		
21127	8012	Hard - Plastic	0.50
24524	9301	Soft - Plastic	0.60
24070	9128	Glass	0.05
24835	9419	Tin/Alum.	0.35
22797	8646	Cardboard	0.35
25635	9722	Paper	0.20
23426	8884		
26357	9996		
27927	10591		
23937	9078		
30147	11433		
303686	**R115171**		

Table B.4.1.6: Mass (kg) of recyclables for Mariannhill Park in 2004 and Potential income

	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.043512	**0.105672**	**0.049728**	**0.043512**	**0.03108**	**0.055944**
January	82799	3603	8750	4117	3603	2573	4632
February	77376	3367	8176	3848	3367	2405	4329
March	84559	3679	8936	4205	3679	2628	4731
April	72073	3136	7616	3584	3136	2240	4032
May	75032	3265	7929	3731	3265	2332	4198
June	74875	3258	7912	3723	3258	2327	4189
July	68651	2987	7254	3414	2987	2134	3841
August	84401	3672	8919	4197	3672	2623	4722
September	89068	3876	9412	4429	3876	2768	4983
October	85023	3700	8985	4228	3700	2643	4757
November	92146	4009	9737	4582	4009	2864	5155
December	107799	4691	11391	5361	4691	3350	6031
Total	**993802**	**43242**	**105017**	**49420**	**43242**	**30887**	**55597**

Table B.4.1.6 (Continued)			
Scenario 1b	**Income**	**High Profit**	
0.329448		**Material**	**Unit Price**
27278	17422		
25491	16281	Hard - Plastic	0.50
27858	17792	Soft - Plastic	1.00
23744	15165	Glass	0.05
24719	15788	Tin/Alum.	0.50
24667	15755	Cardboard	0.45
22617	14445	Paper	0.80
27806	17759		
29343	18741		
28011	17890		
30357	19389		
35514	22682		
327406	**R209107**		

Table B.4.1.6 (Continued)			
Scenario 1b	**Income**	**Low Profit**	
0.329448		**Material**	**Unit Price**
27278	11657		
25491	10894	Hard - Plastic	0.50
27858	11905	Soft - Plastic	0.80
23744	10147	Glass	0.05
24719	10564	Tin/Alum.	0.50
24667	10542	Cardboard	0.15
22617	9666	Paper	0.10
27806	11883		
29343	12540		
28011	11971		
30357	12973		
35514	15177		
327406	**R139920**		

Table B.4.1.7: Mass (kg) of recyclables for Nazareth in 2003 and Potential Income							
	Mass of Waste	**Hard Plastics**	**Soft plastics**	**Glass**	**Tin/Alu.**	**Cardboard**	**Paper**
		0.03723	0.155125	0.043435	0.03723	0.07446	0.080665
January	21700	808	3366	943	808	1616	1750
February	18420	686	2857	800	686	1372	1486
March	16380	610	2541	711	610	1220	1321
April	25920	965	4021	1126	965	1930	2091
May	17380	647	2696	755	647	1294	1402
June	17780	662	2758	772	662	1324	1434
July	20520	764	3183	891	764	1528	1655
August	17300	644	2684	751	644	1288	1396
September	20540	765	3186	892	765	1529	1657
October	25640	955	3977	1114	955	1909	2068
November	21600	804	3351	938	804	1608	1742
December	31460	1171	4880	1366	1171	2343	2538
Total	**254640**	**9480**	**39501**	**11060**	**9480**	**18960**	**20541**

Table B.4.1.7 (Continued)			
Scenario 1b	**Income**	**High Profit**	
0.428145		**Material**	**Unit Price**
9291	4672		
7886	3966	Hard - Plastic	0.50
7013	3527	Soft - Plastic	0.60
11098	5581	Glass	0.10
7441	3742	Tin/Alum.	0.35
7612	3828	Cardboard	0.40
8786	4418	Paper	0.70
7407	3725		
8794	4423		
10978	5521		
9248	4651		
13469	6774		
109023	**R54827**		

Table B.4.1.7 (Continued)			
Scenario 1b	**Income**	**Low Profit**	
0.428145		**Material**	**Unit Price**
9291	3669		
7886	3115	Hard - Plastic	0.50
7013	2770	Soft - Plastic	0.60
11098	4383	Glass	0.05
7441	2939	Tin/Alum.	0.35
7612	3006	Cardboard	0.35
8786	3470	Paper	0.20
7407	2925		
8794	3473		
10978	4335		
9248	3652		
13469	5319		
109023	**R43056**		

Table B.4.1.8: Mass (kg) of recyclables for Nazareth in 2004 and Potential Income							
	Mass of Waste	**Hard Plastics**	**Soft plastics**	**Glass**	**Tin/Alu.**	**Cardboard**	**Paper**
		0.03723	**0.155125**	**0.043435**	**0.03723**	**0.07446**	**0.080665**
January	11820	440	1834	513	440	880	953
February	19920	742	3090	865	742	1483	1607
March	24420	909	3788	1061	909	1818	1970
April	22120	824	3431	961	824	1647	1784
May	21120	786	3276	917	786	1573	1704
June	20520	764	3183	891	764	1528	1655
July	20260	754	3143	880	754	1509	1634
August	23340	869	3621	1014	869	1738	1883
September	21520	801	3338	935	801	1602	1736
October	23380	870	3627	1016	870	1741	1886
November	19780	736	3068	859	736	1473	1596
December	26740	996	4148	1161	996	1991	2157
Total	**254940**	**9491**	**39548**	**11073**	**9491**	**18983**	**20565**

Table B.4.1.8 (Continued)			
Scenario 1b	**Income**	**High Profit**	
0.428145		**Material**	**Unit Price**
5061	3458		
8529	5828	Hard - Plastic	0.50
10455	7144	Soft - Plastic	1.00
9471	6472	Glass	0.05
9042	6179	Tin/Alum.	0.50
8786	6003	Cardboard	0.45
8674	5927	Paper	0.80
9993	6828		
9214	6296		
10010	6840		
8469	5787		
11449	7823		
109151	**R74587**		

Table B.4.1.8 (Continued)			
Scenario 1b	**Income**	**Low Profit**	
0.428145		**Material**	**Unit Price**
5061	2160		
8529	3640	Hard - Plastic	0.50
10455	4462	Soft - Plastic	0.80
9471	4042	Glass	0.05
9042	3859	Tin/Alum.	0.50
8786	3750	Cardboard	0.15
8674	3702	Paper	0.10
9993	4265		
9214	3933		
10010	4272		
8469	3615		
11449	4886		
109151	**R46587**		

Table B.4.1.9: Mass (kg) of recyclables for Mariannhill Park in 2003 and Potential Income							
	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.0158	**0.0453**	**0.0233**	**0.0079**	**0.0972**	**0.0485**
January	87734	1386	3974	2044	693	8528	4255
February	64127	1013	2905	1494	507	6233	3110
March	74440	1176	3372	1734	588	7236	3610
April	73062	1154	3310	1702	577	7102	3544
May	75384	1191	3415	1756	596	7327	3656
June	69197	1093	3135	1612	547	6726	3356
July	77811	1229	3525	1813	615	7563	3774
August	71107	1123	3221	1657	562	6912	3449
September	80005	1264	3624	1864	632	7776	3880
October	84768	1339	3840	1975	670	8239	4111
November	72658	1148	3291	1693	574	7062	3524
December	91509	1446	4145	2132	723	8895	4438
Total	**921802**	**14564**	**41758**	**21478**	**7282**	**89599**	**44707**

Table B.4.1.9 (Continued)			
		High Profit	
Scenario 3	Income	Material	Unit Price
0.238			
20881	9914	Hard - Plastic	0.50
15262	7247	Soft - Plastic	0.60
17717	8412	Glass	0.10
17389	8256	Tin/Alum.	0.35
17941	8519	Cardboard	0.40
16469	7820	Paper	0.70
18519	8793		
16923	8035		
19041	9041		
20175	9579		
17293	8211		
21779	10341		
219389	**R104168**		

Table B.4.1.9 (Continued)			
		Low Profit	
Scenario 3	Income	Material	Unit Price
0.238			
20881	7258	Hard - Plastic	0.50
15262	5305	Soft - Plastic	0.60
17717	6158	Glass	0.05
17389	6044	Tin/Alum.	0.35
17941	6237	Cardboard	0.35
16469	5725	Paper	0.20
18519	6437		
16923	5883		
19041	6619		
20175	7013		
17293	6011		
21779	7571		
219389	**R76261**		

Table B.4.1.10: Mass (kg) of recyclables for Mariannhill Park in 2004 and Potential Income

	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.0158	**0.0453**	**0.0233**	**0.0079**	**0.0972**	**0.0485**
January	82799	1308	3751	1929	654	8048	4016
February	77376	1223	3505	1803	611	7521	3753
March	84559	1336	3831	1970	668	8219	4101
April	72073	1139	3265	1679	569	7005	3496
May	75032	1186	3399	1748	593	7293	3639
June	74875	1183	3392	1745	592	7278	3631
July	68651	1085	3110	1600	542	6673	3330
August	84401	1334	3823	1967	667	8204	4093
September	89068	1407	4035	2075	704	8657	4320
October	85023	1343	3852	1981	672	8264	4124
November	92146	1456	4174	2147	728	8957	4469
December	107799	1703	4883	2512	852	10478	5228
Total	**993802**	**15702**	**45019**	**23156**	**7851**	**96598**	**48199**

Table B.4.1.10 (Continued)			
		High Profit	
Scenario 3	**Income**	**Material**	**Unit Price**
0.238			
19706	11663	Hard - Plastic	0.50
18415	10899	Soft - Plastic	1.00
20125	11911	Glass	0.05
17153	10152	Tin/Alum.	0.50
17858	10569	Cardboard	0.45
17820	10547	Paper	0.80
16339	9670		
20087	11888		
21198	12546		
20235	11976		
21931	12979		
25656	15184		
236525	**R139982**		

Table B.4.1.10 (Continued)			
		Low Profit	
Scenario 3	**Income**	**Material**	**Unit Price**
0.238			
19706	5687	Hard - Plastic	0.50
18415	5315	Soft - Plastic	0.80
20125	5808	Glass	0.05
17153	4950	Tin/Alum.	0.50
17858	5154	Cardboard	0.15
17820	5143	Paper	0.10
16339	4715		
20087	5797		
21198	6118		
20235	5840		
21931	6329		
25656	7404		
236525	**R68259**		

Table B.4.1.11: Mass (kg) of recyclables for Nazareth in 2003 and Potential Income							
	Mass of Waste	Hard Plastics	Soft plastics	Glass	Tin/Alu.	Cardboard	Paper
		0.0158	**0.0453**	**0.0233**	**0.0079**	**0.0972**	**0.0485**
January	21700	343	983	506	171	2109	1052
February	18420	291	834	429	146	1790	893
March	16380	259	742	382	129	1592	794
April	25920	410	1174	604	205	2519	1257
May	17380	275	787	405	137	1689	843
June	17780	281	805	414	140	1728	862
July	20520	324	930	478	162	1995	995
August	17300	273	784	403	137	1682	839
September	20540	325	930	479	162	1996	996
October	25640	405	1161	597	203	2492	1244
November	21600	341	978	503	171	2100	1048
December	31460	497	1425	733	249	3058	1526
Total	**254640**	**4023**	**11535**	**5933**	**2012**	**24751**	**12350**

Table B.4.1.11 (Continued)			
		High Profit	
Scenario 3	**Income**	**Material**	**Unit Price**
0.238			
5165	2452	Hard - Plastic	0.50
4384	2082	Soft - Plastic	0.60
3898	1851	Glass	0.10
6169	2929	Tin/Alum.	0.35
4136	1964	Cardboard	0.40
4232	2009	Paper	0.70
4884	2319		
4117	1955		
4889	2321		
6102	2897		
5141	2441		
7487	3555		
60604	**R28776**		

Table B.4.1.11 (Continued)			
		Low Profit	
Scenario 3	**Income**	**Material**	**Unit Price**
0.238			
5165	1795	Hard - Plastic	0.50
4384	1524	Soft - Plastic	0.60
3898	1355	Glass	0.05
6169	2144	Tin/Alum.	0.35
4136	1438	Cardboard	0.35
4232	1471	Paper	0.20
4884	1698		
4117	1431		
4889	1699		
6102	2121		
5141	1787		
7487	2603		
60604	**R21066**		

Table B.4.1.12: Mass (kg) of recyclables for Nazareth in 2004 and Potential Income							
	Mass of Waste	**Hard Plastics**	**Soft plastics**	**Glass**	**Tin/Alu.**	**Cardboard**	**Paper**
		0.0158	**0.0453**	**0.0233**	**0.0079**	**0.0972**	**0.0485**
January	11820	187	535	275	93	1149	573
February	19920	315	902	464	157	1936	966
March	24420	386	1106	569	193	2374	1184
April	22120	349	1002	515	175	2150	1073
May	21120	334	957	492	167	2053	1024
June	20520	324	930	478	162	1995	995
July	20260	320	918	472	160	1969	983
August	23340	369	1057	544	184	2269	1132
September	21520	340	975	501	170	2092	1044
October	23380	369	1059	545	185	2273	1134
November	19780	313	896	461	156	1923	959
December	26740	422	1211	623	211	2599	1297
Total	**254940**	**4028**	**11549**	**5940**	**2014**	**24780**	**12365**

Table B.4.1.12 (Continued)			
		High Profit	
Scenario 3	**Income**	**Material**	**Unit Price**
0.238			
2813	1336	Hard - Plastic	0.50
4741	2251	Soft - Plastic	0.60
5812	2760	Glass	0.10
5265	2500	Tin/Alum.	0.35
5027	2387	Cardboard	0.40
4884	2319	Paper	0.70
4822	2289		
5555	2638		
5122	2432		
5564	2642		
4708	2235		
6364	3022		
60676	**R28809**		

Table B.4.1.12 (Continued)			
		Low Profit	
Scenario 3	**Ideal**	**Material**	**Unit Price**
0.238			
2813	812	Hard - Plastic	0.50
4741	1368	Soft - Plastic	0.80
5812	1677	Glass	0.05
5265	1519	Tin/Alum.	0.50
5027	1451	Cardboard	0.15
4884	1409	Paper	0.10
4822	1392		
5555	1603		
5122	1478		
5564	1606		
4708	1359		
6364	1837		
60676	**R17511**		

B.4.2 High Profit Results

Table B.4.2.1: Domestic waste generation for status quo (Scenario 2) - 2003

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	922 tons	255 tons	1176	980 m^3
Recyclable	276 tons	76 tons	353	294 m^3
Disposable	645 tons	178 tons	824	686 m^3

Table B.4.2.2: Cost Benefit Analysis for 2003 (Scenario 2)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1176 tons	200 R/ton	R 235,289
Disposal	Capital	980 m^3	27.35 R/m^3	R 26,813
	Operational	980 m^3	95.74 R/m^3	R 90,736
Total Costs				R 352,838
Recycling Scheme				
Collection		1176 tons	200 R/ton	R 235,289
Disposal	Capital	686 m^3	27.35 R/m^3	R 18,771
	Operational	686 m^3	95.74 R/m^3	R 63,522
Transportation		353 tons	100 R/ton	R 35,284
Total costs				R 352,866
Total Savings				-R 29

Table B.4.2.3: Domestic waste generation for proposed ZWS (Scenario 3) – 2003: High Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	922 tons	255 tons	1176 tons	980 m^3
Recyclable	219 tons	61 tons	280 tons	233 m^3
Disposable	702 tons	194 tons	896 tons	747 m^3
Revenue	**R 104,168**	**R 38,776**	**R 132,944**	

Table B.4.2.4: Cost Benefit Analysis for 2003 (Scenario 3) – High Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	980 m^3	R27.35/m^3	R 26,813
	Operational	980 m^3	R92.55/m^3	R 90,736
Total Costs				R 352,838
Recycling Scheme				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	747 m^3	R27.35/m^3	R 20,432
	Operational	747 m^3	R92.55/m^3	R 69,141
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	280 tons	R140/ton	R 39,199
Scheme Benefits	Sale of recyclables			-R 132,944
Total costs				R 281,116
Total Savings				R 71,722

Table B.4.2.5: Benefit/Cost ratio (Scenario 3) – 2003: High Profit)

Net Benefit	R 71,722
Capital	R 50,000
NB/Capital	1.4

Table B.4.2.6: Domestic waste generation for proposed ZWS (Scenario 1a) – 2004: High Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	994 tons	255 tons	1249 tons	1041 m^3
Recyclable	527 tons	176 tons	703 tons	586 m^3
Disposable	467 tons	79 tons	546 tons	455 m^3
Revenue	**R 336,402**	**R 120,204**	**R 456,606**	

Table B.4.2.7: Cost Benefit Analysis for 2004 (Scenario 1a) – High Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	1041 m^3	R27.35/m^3	R 28,461
	Operational	1041 m^3	R92.55/m^3	R 99,633
Total Costs				R 377,842
Recycling Scheme				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	455 m^3	R27.35/m^3	R 12,447
	Operational	455 m^3	R92.55/m^3	R 43,573
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	703 tons	R70/ton	R 49,184
	Marketing Campaigns	3250 Houses	R10/house	R 32,500
	Dual Containers	3250 Bins	R10/Bin	R 32,500
	Collection Bags	340000 Bags	R0.18/bag	R 61,200
Scheme Benefits	Sale of recyclables			-R 456,606
Total costs				-R 74,456
Total Savings				R 303,296

Table B.4.2.8: Benefit/Cost ratio (Scenario 1a) – 2004: High Profit)

Net Benefit	R 303,296
Capital	R 50,000
NB/Capital	6.1

Table B.4.2.9: Domestic waste generation for proposed ZWS (Scenario 1b) - 2004: High Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	994 tons	255 tons	1249	1041 m^3
Recyclable	327 tons	109 tons	437	364 m^3
Disposable	666 tons	146 tons	812	677 m^3
Revenue	**R 209,107**	**R 74,587**	**R 283,694**	

Table B.4.2.10: Cost Benefit Analysis for 2004 (Scenario 1b) - High Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	1041 m^3	R27.35/m^3	R 28,461
	Operational	1041 m^3	R92.55/m^3	R 99,633
Total Costs				R 377,842
Recycling Scheme				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	677 m^3	R27.35/m^3	R 18,511
	Operational	677 m^3	R92.55/m^3	R 64,802
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	437 tons	R70/ton	R 30,559
	Marketing Campaigns	2405 Houses	R10/house	R 24,050
	Dual Containers	2405 Bins	R10/Bin	R 24,050
	Collection Bags	251600 Bags	R0.18/bag	R 45,288
Scheme Benefits	Sale of recyclables			-R 283,694
Total costs				R 223,314
Total Savings				R 154,528

Table B.4.2.11: Benefit/Cost ratio (Scenario 1b) - 2004: High Profit)

Net Benefit	R 154,528
Capital	R 50,000
NB/Capital	3.1

Table B.4.2.12: Domestic waste generation for status quo (Scenario 2) - 2004

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	994 tons	255 tons	1249 tons	1041 m^3
Recyclable	298 tons	76 tons	375 tons	312 m^3
Disposable	696 tons	178 tons	874 tons	728 m^3

Table B.4.2.14: Cost Benefit Analysis for 2004 (Scenario 2)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1249 tons	200 R/ton	R 249,748
Disposal	Capital	1041 m^3	27.35 R/m^3	R 28,461
	Operational	1041	95.74 R/m^3	R 99,633
Total Costs				R 377,842
Recycling Scheme				
Collection		1249 tons	200 R/ton	R 249,748
Disposal	Capital	728 m^3	27.35 R/m^3	R 19,923
	Operational	728 m^3	95.74 R/m^3	R 69,743
Transportation		375 tons	100 R/ton	R 37,462
Total costs				R 376,876
Total Savings				R 966

Table B.4.2.13: Domestic waste generation for proposed ZWS (Scenario 3) – 2004: High Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	994 tons	255 tons	1249 tons	1041 m^3
Recyclable	237 tons	61 tons	297 tons	248 m^3
Disposable	757 tons	194 tons	952 tons	793 m^3
Revenue	**R 139,982**	**R 28,809**	**R 168,791**	

Table B.4.2.14: Cost Benefit Analysis for 2004 (Scenario 3) – High Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	1041 m^3	R27.35/m^3	R 28,461
	Operational	1041 m^3	R92.55/m^3	R 99,633
Total Costs				R 377,842
Recycling Scheme				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	793 m^3	R27.35/m^3	R 21,687
	Operational	793 m^3	R92.55/m^3	R 75,920
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	297 tons	R140/ton	R 41,608
Scheme Benefits	Sale of recyclables			-R 168,791
Total costs				R 270,173
Total Savings				R 107,669

Table B.4.2.15: Benefit/Cost ratio (Scenario 3) – 2004: High Profit)

Net Benefit	R 107,669
Capital	R 50,000
NB/Capital	2.2

B.4.3 Low Profit Results

Table B.4.3.1: Domestic waste generation for proposed ZWS (Scenario 3) - 2003: Low Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	922 tons	255 tons	1176 tons	980 m^3
Recyclable	219 tons	61 tons	280 tons	233 m^3
Disposable	702 tons	194 tons	896 tons	747 m^3
Revenue	**R 76,261**	**R 21,066**	**R 97,327**	

Table B.4.3.2: Cost Benefit Analysis for 2003 (Scenario 3) - Low Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	980 m^3	R27.35/m^3	R 26,813
	Operational	980 m^3	R92.55/m^3	R 90,736
Total Costs				R 352,838
Recycling Scheme				
Collection		1176 tons	R200/ton	R 235,289
Disposal	Capital	747 m^3	R27.35/m^3	R 20,432
	Operational	747 m^3	R92.55/m^3	R 69,141
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	280 tons	R140/ton	R 39,199
Scheme Benefits	Sale of recyclables			-R 97,237
Total costs				R 316,733
Total Savings				R 36,105

Table B.4.3.3: Benefit/Cost ratio (Scenario 3) - 2003: Low Profit)

Net Benefit	R 36,105
Capital	R 50,000
NB/Capital	0.7

Table B.4.3.4: Domestic waste generation for proposed ZWS (Scenario 1a) – 2004: Low Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	994 tons	255 tons	1249 tons	1041 m^3
Recyclable	527 tons	176 tons	703 tons	586 m^3
Disposable	467 tons	79 tons	546 tons	455 m^3
Revenue	**R 225,096**	**R 75,080**	**R 300,176**	

Table B.4.3.5: Cost Benefit Analysis for 2004 (Scenario 1a) – Low Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	1041 m^3	R27.35/m^3	R 28,461
	Operational	1041 m^3	R92.55/m^3	R 99,633
Total Costs				R 377,842
Recycling Scheme				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	455 m^3	R27.35/m^3	R 12,447
	Operational	455 m^3	R92.55/m^3	R 43,573
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	703 tons	R70/ton	R 49,184
	Marketing Campaigns	3250 Houses	R10/house	R 32,500
	Dual Containers	3250 Bins	R10/Bin	R 32,500
	Collection Bags	340000 Bags	R0.18/bag	R 61,200
Scheme Benefits	Sale of recyclables			-R 300,176
Total costs				R 230,976
Total Savings				R 146,866

Table B.4.3.6: Benefit/Cost ratio (Scenario 1a) – 2004: Low Profit)

Net Benefit	R 146,866
Capital	R 50,000
NB/Capital	2.9

Table B.4.3.7: Domestic waste generation for proposed ZWS (Scenario 1b) – 2004: Low Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	994 tons	255 tons	1249 tons	1041 m^3
Recyclable	327 tons	109 tons	437 tons	364 m^3
Disposable	666 tons	146 tons	812 tons	677 m^3
Revenue	**R 139,920**	**R 46,587**	**R 186,507**	

Table B.4.3.8: Cost Benefit Analysis for 2004 (Scenario 1b) – Low Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	1041 m^3	R27.35/m^3	R 28,461
	Operational	1041 m^3	R92.55/m^3	R 99,633
Total Costs				R 377,842
Recycling Scheme				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	677 m^3	R27.35/m^3	R 18,511
	Operational	677 m^3	R92.55/m^3	R 64,802
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	437 tons	R70/ton	R 30,559
	Marketing Campaigns	2405 Houses	R10/house	R 24,050
	Dual Containers	2405 Bins	R10/Bin	R 24,050
	Collection Bags	251600 Bags	R0.18/bag	R 45,288
Scheme Benefits	Sale of recyclables			-R 186,507
Total costs				R 320,501
Total Savings				R 57,341

Table B.4.3.9: Benefit/Cost ratio (Scenario 1b) – 2004: Low Profit)

Net Benefit	R 57,341
Capital	R 50,000
NB/Capital	1.1

Table B.4.3.10: Domestic waste generation for proposed ZWS (Scenario 3) – 2004: Low Profit)

Label	Mariannhill Park	Nazareth	Total	Volume
Total Waste	994 tons	255 tons	1249 tons	1041 m^3
Recyclable	237 tons	61 tons	297 tons	248 m^3
Disposable	757 tons	194 tons	952 tons	793 m^3
Revenue	**R 68,259**	**R 17,511**	**R 85,770**	

Table B.4.3.11: Cost Benefit Analysis for 2004 (Scenario 3) – Low Profit)

		Quantity	Rate	Amount
Current Modus Operandi				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	1041 m^3	R27.35/m^3	R 28,461
	Operational	1041 m^3	R92.55/m^3	R 99,633
Total Costs				R 377,842
Recycling Scheme				
Collection		1249 tons	R200/ton	R 249,748
Disposal	Capital	793 m^3	R27.35/m^3	R 21,687
	Operational	793 m^3	R92.55/m^3	R 75,920
Scheme Costs				
	Capital (MRF)			R 50,000
	Operational (MRF)	297 tons	R140/ton	R 41,608
Scheme Benefits	Sale of recyclables			-R 85,770
Total costs				R 353,194
Total Savings				R 24,648

Table B.4.3.12: Benefit/Cost ratio (Scenario 3) – 2004: Low Profit)

Net Benefit	R 24,648
Capital	R 50,000
NB/Capital	0.5

ADDENDA

C1: Journal Publication

JOURNAL OF WASTE MANAGEMENT

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Towards Zero Waste in emerging countries – A South African experience

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Abstract

The aim of this paper is to describe the optimisation of Waste Minimisation/Zero Waste strategies into an already established integrated waste management system and to present a Zero Waste model for post-consumer waste for urban communities in South Africa. The research was undertaken towards the fulfilment of the goals of the Polokwane Declaration on Waste Management [DEAT, 2001. Department of Environmental Affairs and Tourism, Government of South Africa. Polokwane Declaration. Drafted by Government, Civil Society and the Business Community. National Waste Summit, Polokwane, 26–28 September 2001], which has set as its target the reduction of waste generation and disposal by 50% and 25%, respectively, by 2012 and the development of a plan for Zero Waste by 2022. Two communities, adjacent to the Mariannhill Landfill site in Durban, were selected as a case study for a comparative analysis of formal and informal settlements. Since the waste generated from these two communities is disposed of at the Mariannhill landfill, the impact of Zero Waste on landfill volumes could be readily assessed. A Zero Waste scheme, based on costs and landfill airspace savings, was proposed for the area. The case study demonstrates that waste minimisation schemes can be introduced into urban areas, in emerging countries, with differing levels of service and that Zero Waste models are appropriate to urban areas in South Africa.

1. Introduction

According to Onu (2000), solid waste management in developing countries is characterised by highly inefficient waste collection practices, variable and inadequate levels of service due to limited resources, lack of environmental control systems, indiscriminate dumping, littering and scavenging and, most of all, poor environmental and waste awareness of the general public.

In general, the organisation and planning of public waste collection service in developing countries is very rudimentary (Buenrostro and Bocco, 2003). In India, for example, the collection, transportation and disposal of municipal solid waste (MSW) are unscientific and chaotic (Gupta et al., 1998). Limited amounts of MSW are recycled and recovered (Buenrostro and Bocco, 2003) and recycling remains essentially an informal activity (Agarwal et al., 2004). In most urban areas in emerging/developing countries, solid waste management costs consume between 20% and 50% of municipal revenues (Altaf and Deshazo, 1996; Henry et al., 2006), yet the waste collection service levels remain low with only between 50% and 70% of residents served and most of the disposal being conducted in an unsafe manner (Buenrostro and Bocco, 2003; Henry et al., 2006; Kaseva and Mbuligwe, 2005).

South Africa, as an emerging nation, is facing the challenge of meeting high standards in service delivery with limited resources. The disparity in service coverage between different communities in the same area is a characteristic of waste management practices in South Africa. Anon., 2003 indicates that environmentally and socially unacceptable practices characterise many aspects of waste management; in many of those urban areas that have always had poor delivery, those services collapsed as a result of poor financial planning (Anon., 2003). In 2000, the Local Government

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Table 1
Statistics on recycling in South Africa

Product	Percentage recycled				
	1991	1992	1998	2000	Average
Paper and board	28.4	29	38	89	46
Plastics	14.8	11	12	29	17
Tinplate	26.3	21	67	46	39
Aluminium	29.6	36	45		
Glass	22.4	14	12.6	20	17
Average	24.3	22.2	34.9	46.0	30

Sources: Lombard (1997), Wiechers et al. (2002), Ridl (2003), Hugo (2004).

Table 2
Composition of the recyclable fractions in the waste streams

Recyclable fraction	Mariannhill Park (% by mass)	Nazareth (% by mass)
Hard plastics	7	6
Soft plastics	17	25
Glass	8	7
Cans (tin/aluminium)	7	6
Cardboard	5	12
Other paper	9	13
Total	53	69

Source: SKC (2002b).

Municipal Systems Act (No. 32, 2000) was enacted to address the imbalance in service delivery. The Act requires that municipalities strive to ensure that services are provided to local communities in a financially and environmentally sustainable manner, and that local communities have equitable access to such services. In 1998, the South African Department of Environmental Affairs and Tourism (DEAT) introduced the concept of waste hierarchy (Reduce – Reuse – Recover – Dispose) into the environmental legislation, as the only possible road towards sustainable development (National Environmental Management Act No. 107, 1998). It is within the waste hierarchy that waste minimisation emerges as a tool to integrate waste reduction, reuse and recovery (recycling). Whereas waste minimisation focuses on reducing the amount of waste generated, the concept of Zero Waste goes further. Zero Waste maximises recycling, minimises waste, reduces consumption and ensures that products are made to be reused, repaired or recycled back into nature or the market place. Unlike other emerging countries, South Africa has a well established recycling industry, although there is no specific legislation enforcing or addressing recycling (DEAT, 1996; Borland et al., 2000). Current methods of publicly-run recycling include organised scavenging, drop-off centres and buy-back centres. Scavenging (informal recycling) takes place on landfill sites or transfer stations and achieves less than 1% reduction in the waste stream (des Ligneris, 2000; Ridl, 2003). Drop-off centres, which are operated by municipalities and used by the general public, also achieve less than 1% reduction (des Ligneris, 2000; Ridl, 2003). With buy-back centres, recyclable waste is collected manually, usually by scavengers, and also contributes to a negligible waste reduction (des Ligneris, 2000).

Most of the recycling in South Africa is conducted by the packaging industry (DEAT, 1999). Collection of recyclable materials occurs mainly through private entrepreneurs and agents for the different recycling companies (DEAT, 1996). Table 1 gives an indication of the statistics on recycling in South Africa, while Table 2 presents typical recycling and recovery costs for cardboard. The lack of a general trend is indicative of the market-driven nature of the recycling industry, which remains vulnerable and heavily dependent on the availability of markets for the recyclables (DEAT, 1996).

The aim of this paper is to describe the necessary steps towards the optimisation of Waste Minimisation/Zero Waste strategies into an already established integrated

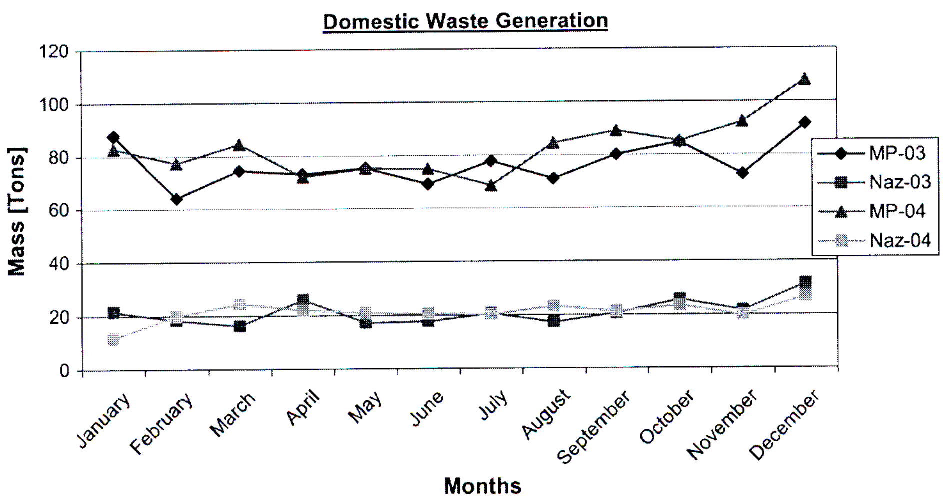

Fig. 1. Variation of the total waste stream in Mariannhill Park and Nazareth (2003–2004).

waste management system and the development of a Zero Waste model for post-consumer waste in urban communities in South Africa. The concept of Zero Waste may be applicable to any part of the waste stream, from production to disposal. It is a 'back end' solution that maximises recycling and minimises waste. In this research a Zero Waste model was formulated for post-consumer waste rather than production waste, with particular emphasis on domestic solid waste. Two communities, adjacent to the Mariannhill landfill site in Durban, were used as a case study. The Mariannhill Park community represents a middle income area, while Nazareth is a typical low income area. The waste generated in these two areas is disposed of at the Mariannhill sanitary landfill; hence the direct impact of waste minimisation on landfill volumes and financial savings could be readily assessed.

2. Methodological approach

Mariannhill Park and Nazareth are two communities adjacent to the Mariannhill landfill site, about 20 km west of the Durban CBD (Central Business District). The area forms part of the Inner West Region of the eThekwini Municipality. According to SKC (2002a), the Inner West Region comprises 11.2% of the total area of the municipality, with a population size of 631,705 (20.6% of the total municipal population). Households in these areas are subdivided into formal and informal, with 74% of residents

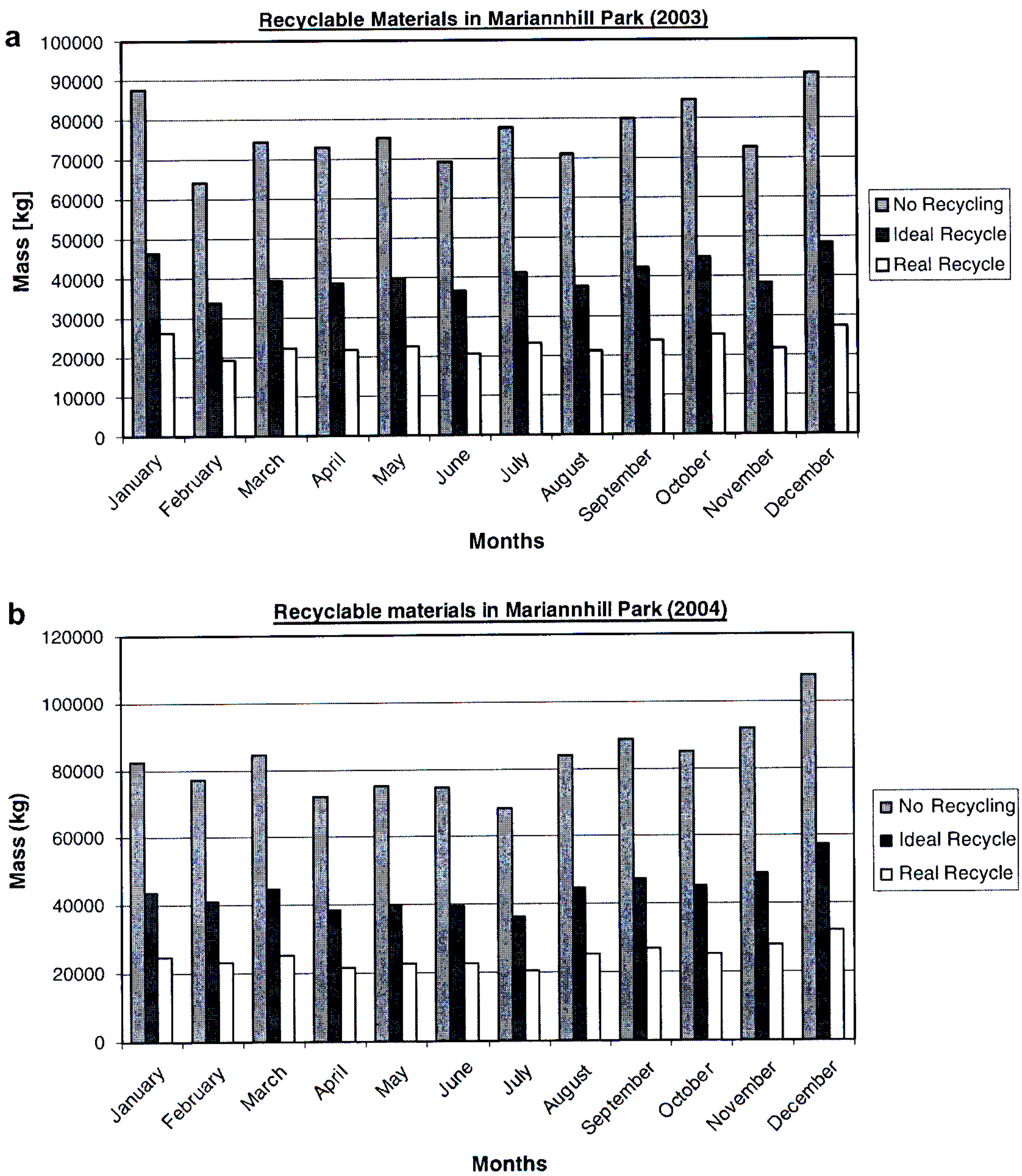

Fig. 2a–b. Recyclable materials for Mariannhill Park (2003–2004).

living in formal housing that produce 95% of the domestic waste (SKC, 2002a). Formal housing includes 2–4 bedroom detached and semi-detached houses and flats, while informal housing includes one room stand-alone and backyard shacks, and low cost houses provided by the Local Government.

An End-Life Cycle Assessment, for 2003 and 2004, was carried out for the recyclable fractions in the waste stream from the two communities, which include paper (high grade white paper and cardboard), plastic (PET, HDPE and LDPE), glass and cans. The nearby Westmead Community Recycling Centre was used to determine the commodity prices for the recyclable materials. The recyclable yield was estimated comparing an ideal and a realistic model. The ideal model assumes that all the available recyclable fractions can be recycled. The realistic model assumes that only 30% of the total solid waste generated in each area is recyclable, as estimated by the average recycling rate in South Africa over a 9-year period (1991–2000) as shown in Table 1 and supported by other studies (Hugo, 2004). A preliminary waste minimisation scheme was proposed with the main aim of demonstrating the benefits that arise from applying waste reduction strategies. A cost–benefit analysis (CBA) was carried out to assess the economic benefits of the proposed waste minimisation scheme as compared to conventional collection and disposal of solid waste. The CBA focuses on landfill cost and landfill space savings, and it also considers the income that could be generated from the sale of the recyclables to suitable buyers. All local prices have been converted to US dollars using an exchange rate of US$1 as equivalent to R6.78 as estimated from 2003 to date.

A questionnaire designed to test the attitudes of the two communities towards waste minimisation and recycling was administered at a pilot-scale in Mariannhill Park and Nazareth to a sample of 70 people from each area. Some of the results of the questionnaire were used in the preliminary design of a Zero Waste scheme.

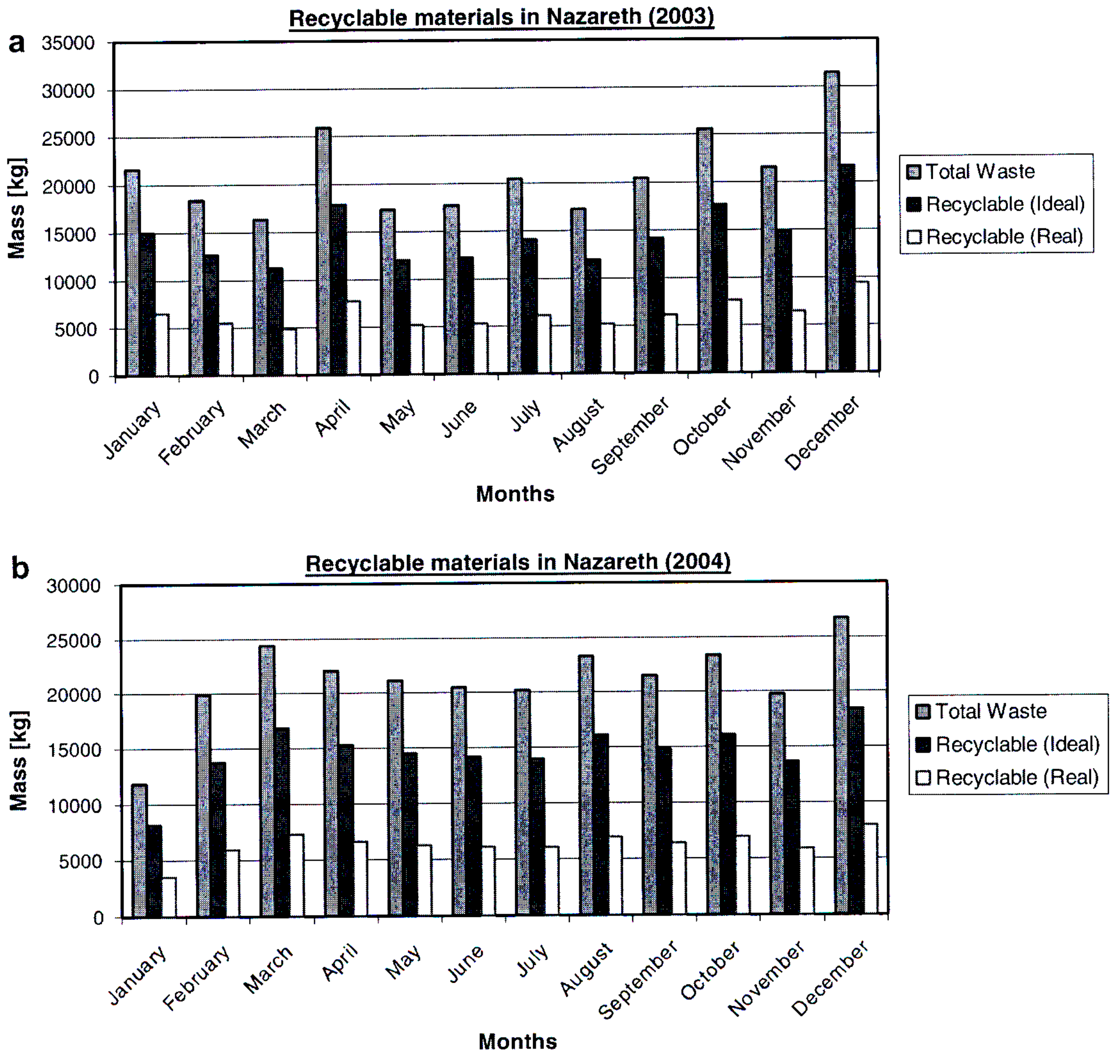

Fig. 3a–b. Recyclable materials for Nazareth (2003–2004).

3. Results and discussion

3.1. The mariannhill case study

Mariannhill Park is a formal, medium income area with a high level of service (55% lower middle income, 45% upper middle income according to The World Bank classification). The number of dwellings is approximately 3000 units (Marshall, 2005), hence using an average of 4.5 people per dwelling (Stats SA, 2002) the population is approximated at 13,500 people. Waste collection is carried out once a week by the municipal waste disposal unit (Durban Solid Waste-DSW). The service is door-to-door, with each dwelling supplied with 2 × 85 l black plastic bags each week. The waste density is assumed as 120 kg/m^3, with an estimated daily per capita waste production of 0.20 kg/person/day (SKC, 2002a). Nazareth is a semi-formal, low income area with a medium level of service (70% lower income and the rest lower middle income according to The World Bank classification). The number of dwellings is estimated at 980–1000 (Marshall, 2005), with a total population of 4410–4500 people. Waste collection is carried out once a week by a contractor appointed by DSW. The service is door-to-door, with each dwelling supplied with 2 × 85 l black plastic bags each week. The waste density is 150 kg/m^3 and the average per capita waste generation rate is 0.16 kg/person/day (SKC, 2002a). The total waste produced in the two areas is shown in Fig. 2a–b.

From Fig. 1, it is evident that the waste generation rates in the two communities did not fluctuate significantly over the years of study. The composition of the recyclables in the waste streams is presented in Table 2. A comparison between the generation of recyclables as estimated by the ideal and the realistic models, with the current status-quo (no recycling) is presented in Figs. 2a–b and 3a–b, respectively, for Mariannhill Park and Nazareth. The recycling output estimated by the realistic

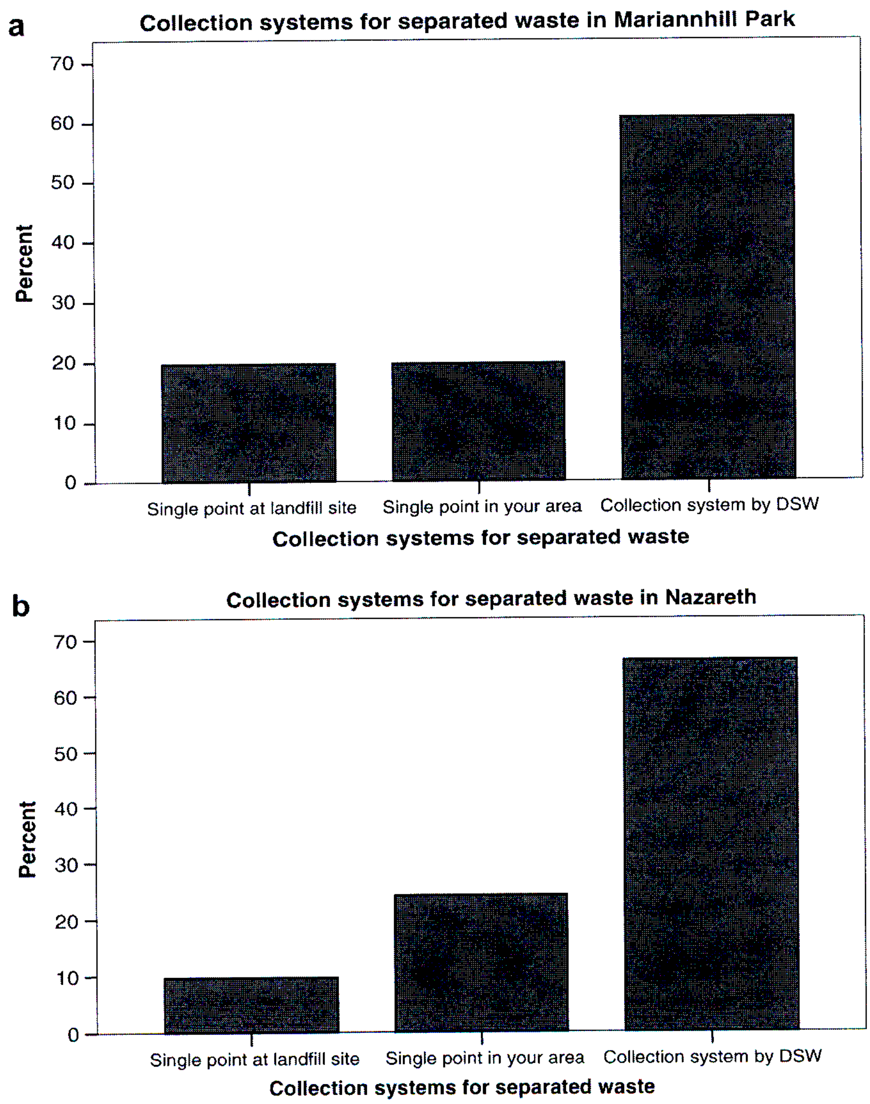

Fig. 4a–b. Preferred collection system for separated waste in Mariannhill Park and Nazareth.

model averages 23 tons/mo, with a range around 19–27 tons/mo for 2003. For 2004, the realistic recycling output averages 25 tons/mo, with a range around 21–32 tons/mo. Thus at least 19 tons/mo can be the expected yield of recyclables from Mariannhill Park, which is also predicted to display a marked increase from one year to the next. From Fig. 3a–b, the realistic recycling output averages around 6.4 tons/mo, with a range of 4.9–9.4 tons/mo for 2003. For 2004, the realistic recycling output averages around 6.4 tons/mo, with a range of 3.5–8.0 tons/mo. Thus at least 3.5 tons/mo can be the expected realistic yield of recyclables from Nazareth. This yield is expected to fluctuate slightly with no noticeable increase in subsequent years.

3.2. Proposed Zero Waste scheme

On the basis of the results of the analysis of the recyclable yields and the information provided by the questionnaire, a waste minimisation scheme was proposed for Mariannhill Park and Nazareth. The scheme is a step up from current waste management system as it lays responsibility on households to recycle their waste at-source. For example, the scheme makes use of existing recycling strategies currently being applied in other urban areas in South Africa. It is a combination of three systems: drop-off, kerbside and central sorting. It takes cognisance of the advantages and disadvantages of each system and the current waste collection methods in the two areas. The results from

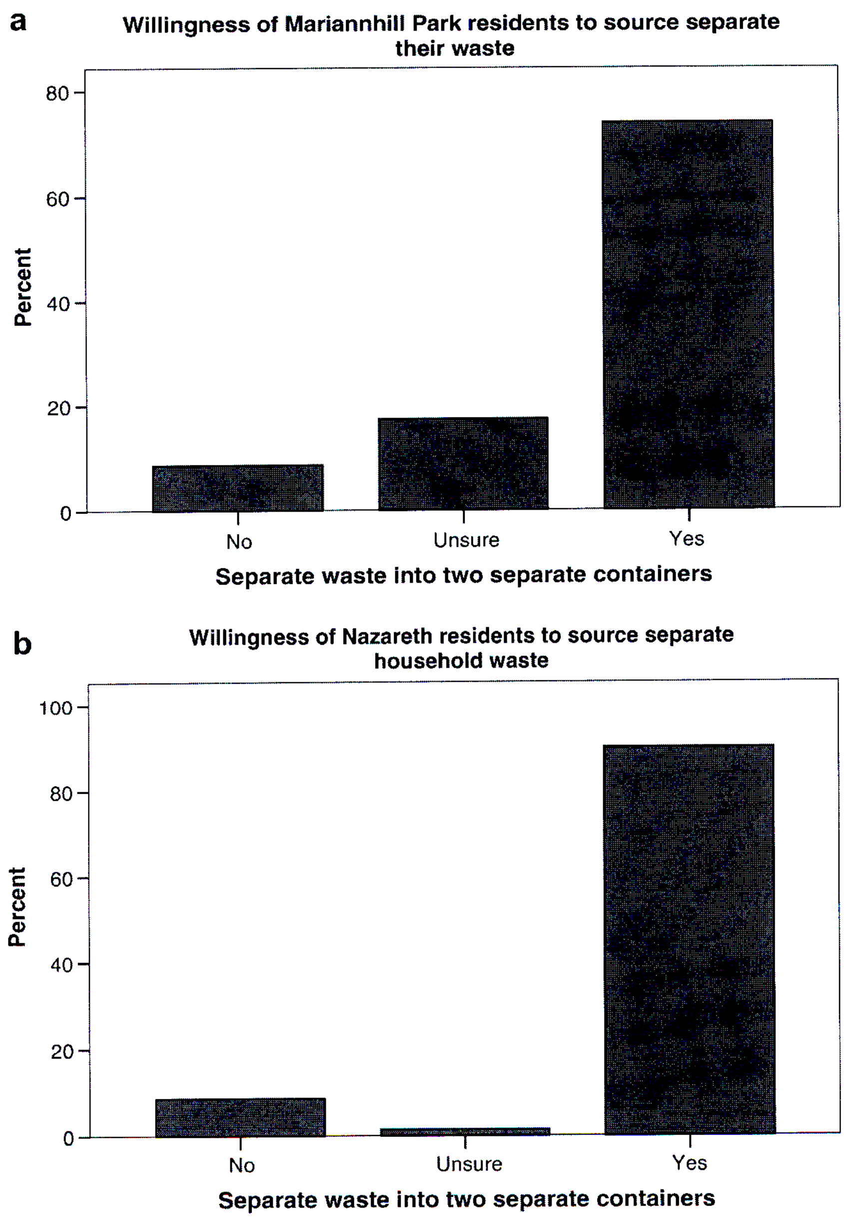

Fig. 5a–b. Willingness of Mariannhill Park and Nazareth residents to source separate their waste.

the questionnaire show that more than 60% of respondents in both areas support kerbside collection of both wet and dry fractions (see Fig. 4a–b).

The scheme is based on a wet/dry model or at-source separation, with more than 80% of surveyed respondents indicating that they would be willing to source separate their waste in dry and wet fractions (see Fig. 5a–b). Different coloured bags would be provided for collection of each fraction. The two fractions would not be allowed to mix as in current waste collection methods. For both Mariannhill Park and Nazareth, separate kerbside collection of both fractions would be undertaken. Recyclables would be then deposited at the existing Mariannhill Transfer Station for manual separation, sorting and storage according to grade and final use.

An educational campaign will need to be conducted in order to encourage participation in the scheme by householders. The major aims of the campaign would be to explain recycling techniques to householders from a life cycle perspective and to motivate positive recycling and waste minimisation behaviour in the community. Results from the questionnaire show that changing the attitude of residents towards protection of the environment, which has been shown to be one of the main drivers of recycling and waste minimisation behaviour (Tonglet et al., 2004), will need to be the thrust of the educational campaign. Among a list of six issues of importance to residents, protection of the environment was ranked as the fourth most important in both Mariannhill Park and Nazareth (see Fig. 6a–b). Hence the aim of the educational campaign will

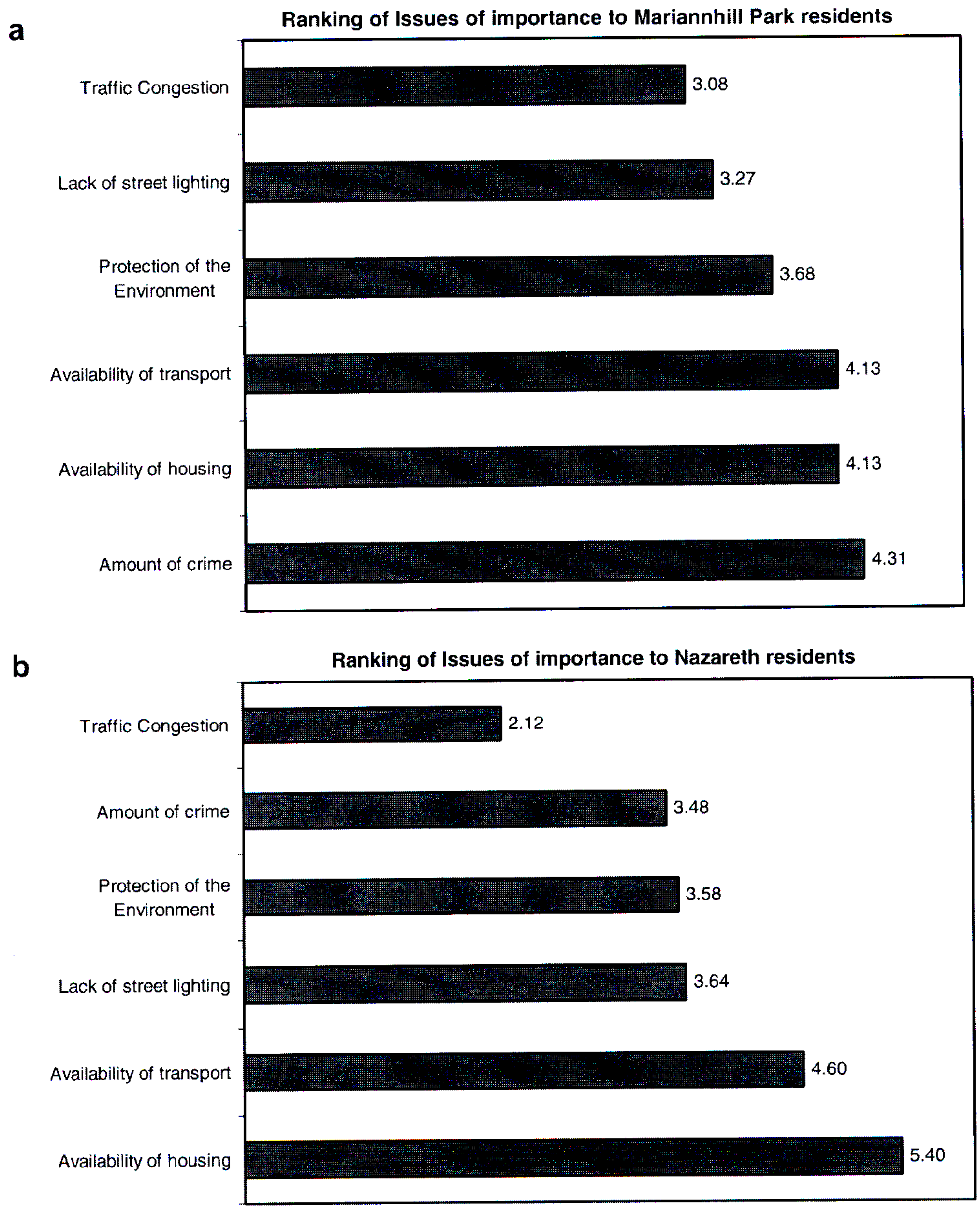

Fig. 6a–b. Relative importance of protection of the environment to Mariannhill Park and Nazareth residents.

be to push protection of the environment to the forefront of important issues that concern the community.

The proposed educational campaign would be divided into an initial campaign to launch the scheme. Leaflets, newspapers, personalised letters, radio, television and public meetings could be used at this stage of the campaign. Thereafter, an ongoing programme to keep householders involved in the scheme will be implemented through regular feedback with the community through the use of mobile phones as indicated by the questionnaire as the preferred method of communication for both areas (Fig. 7a–b).

3.3. Benefits of the Zero Waste scheme: landfill space savings

The landfill space savings, in terms of conserved air volume for the two scenarios investigated, are as shown in Fig. 8a–b for Mariannhill Park and Fig. 9a–b for Nazareth. From Fig. 8a–b, the utilisation of landfill space per month is fairly stable during the year. On average, the ideal model saves 34 m^3/mo (53%) of landfill space for both 2003 and 2004. This results in an actual savings of 28–40 m^3/mo for both years. Assuming that these savings will be constant during the year, at least 28 m^3/mo of landfill space savings should be achieved by the proposed scheme. This savings is expected to increase from one year to the next. The ideal model sets the upper bound for landfill space savings that could be expected for the proposed scheme being applied to Mariannhill Park. On average, the realistic model saves 20 m^3/mo (30%) of landfill space for both 2003 and 2004. This results in an actual savings of 16–27 m^3/mo for both years. It can be derived that at least 16 m^3/mo of landfill space savings should be achieved by

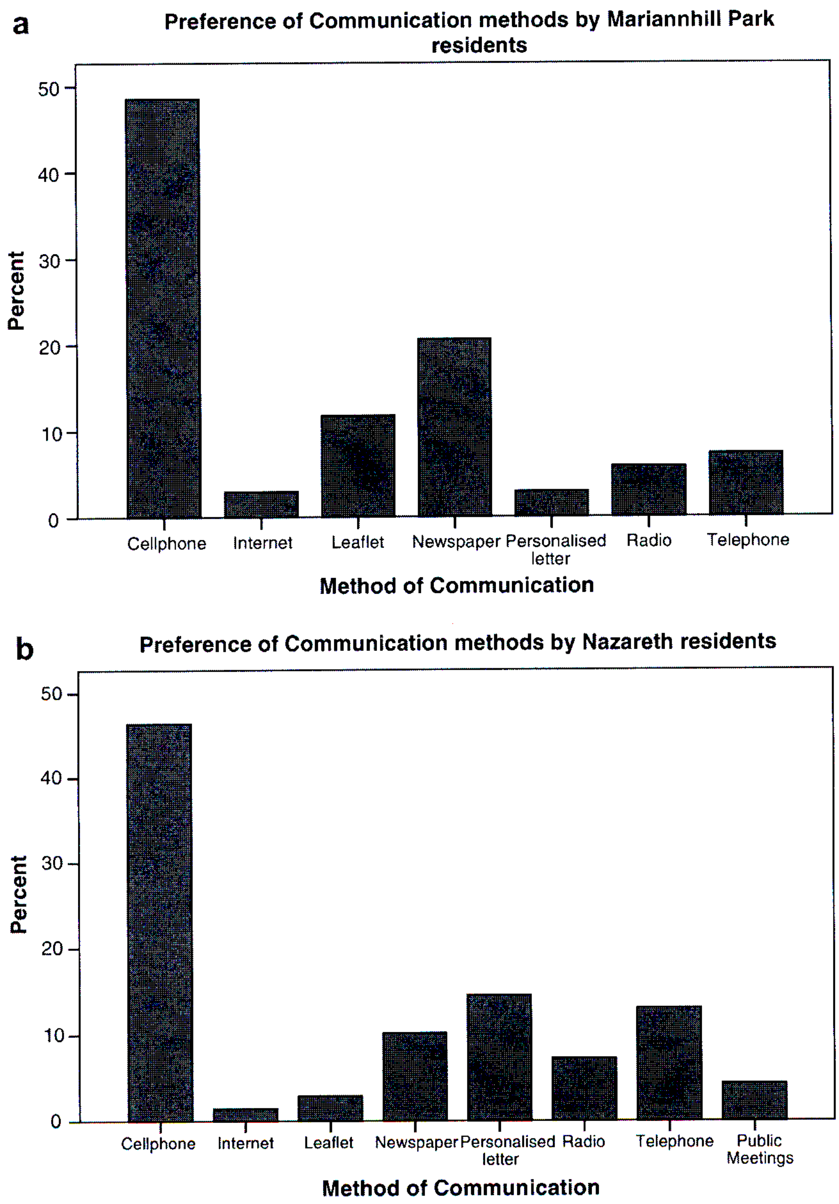

Fig. 7a–b. Preferred methods of communication system about Zero Waste scheme for Mariannhill Park and Nazareth residents.

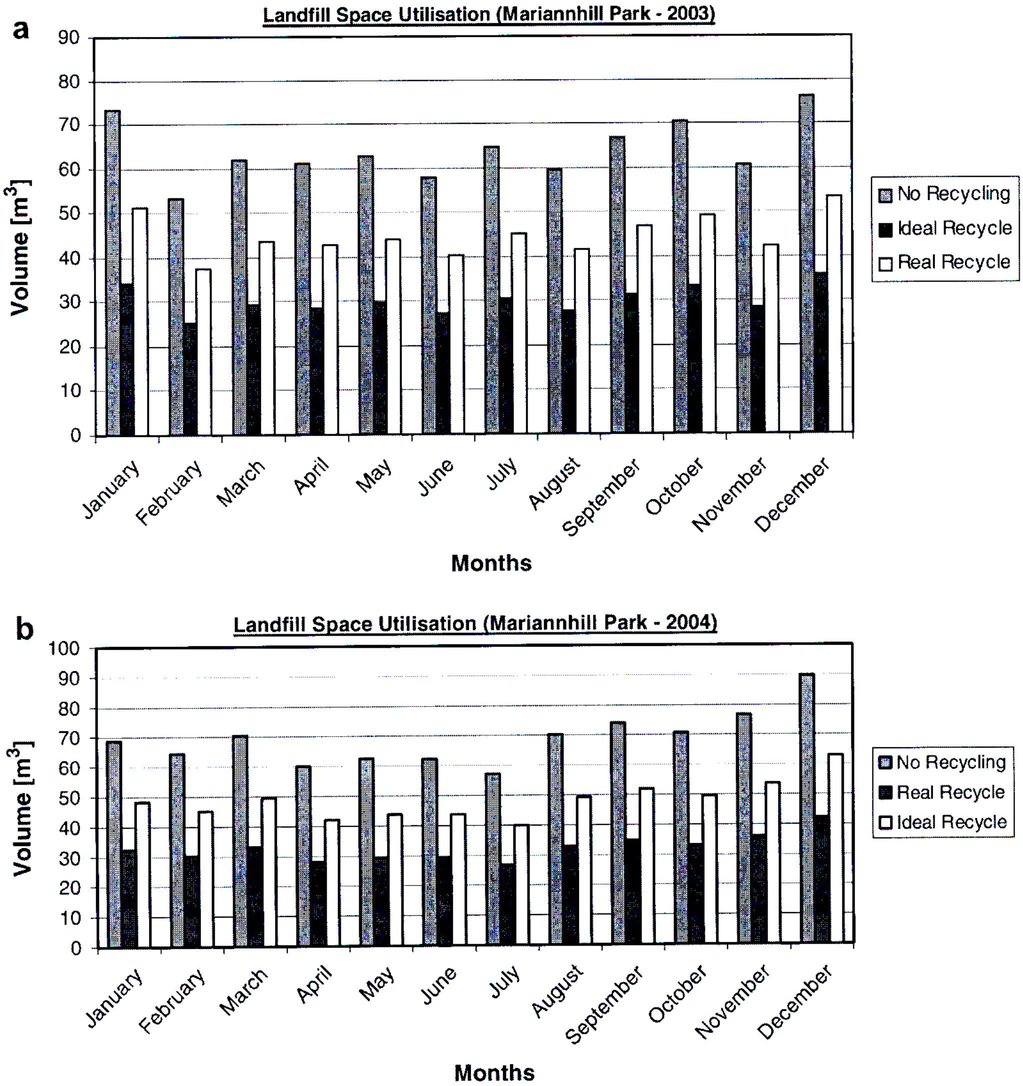

Fig. 8a–b. Landfill space utilisation Mariannhill Park (2003–2004).

the proposed scheme. The realistic model gives an average landfill space savings that could be expected for the proposed scheme being applied to Mariannhill Park. Fig. 9a–b confirms the trend noted in Fig. 8a–b: the utilisation of landfill space per month is fairly stable during the year. On average, the ideal model saves 12 m^3/mo (67%) of landfill space for both 2003 and 2004. This results in an actual saving of 7–15 m^3/mo for both years. Given that these savings are expected to fluctuate seasonally, at least 7 m^3/mo of landfill space savings should be achieved by the proposed scheme. This savings is expected to increase steadily from one year to the next. The ideal model sets the upper bound for landfill space savings that could be expected for the proposed scheme being applied to Nazareth. On average, the realistic model saves 5 m^3/mo (28%) of landfill space for both 2003 and 2004. This results in an actual savings of 3–7 m^3/mo for both years. Given that these savings fluctuate seasonally, at least 3 m^3/mo of landfill space savings should be achieved by the proposed scheme. The realistic model gives an average expectation for landfill space savings that could be expected for the proposed scheme being applied to Nazareth.

3.4. Benefits of the Zero Waste scheme: financial savings

Collection and disposal costs are generally stable in Durban while the average commodity prices for recyclables are highly volatile. This can be seen by the price fluctuation over the last 5 years as shown in Table 3. The drop in price for paper and related products in 2005, although incidental, was responsible for a large fluctuation in the market (Botha, 2005).

A statistical analysis of the selling prices of recyclables shows that glass is the most stable product against paper at the opposite extreme. The other commodities price fluctuations are nested within the two extremes. It is important to note that the three highest commodity prices, that is for paper, plastics and ferrous metals, also display the highest fluctuations. Hence, the economic success of any waste minimisation scheme can be affected by these specific

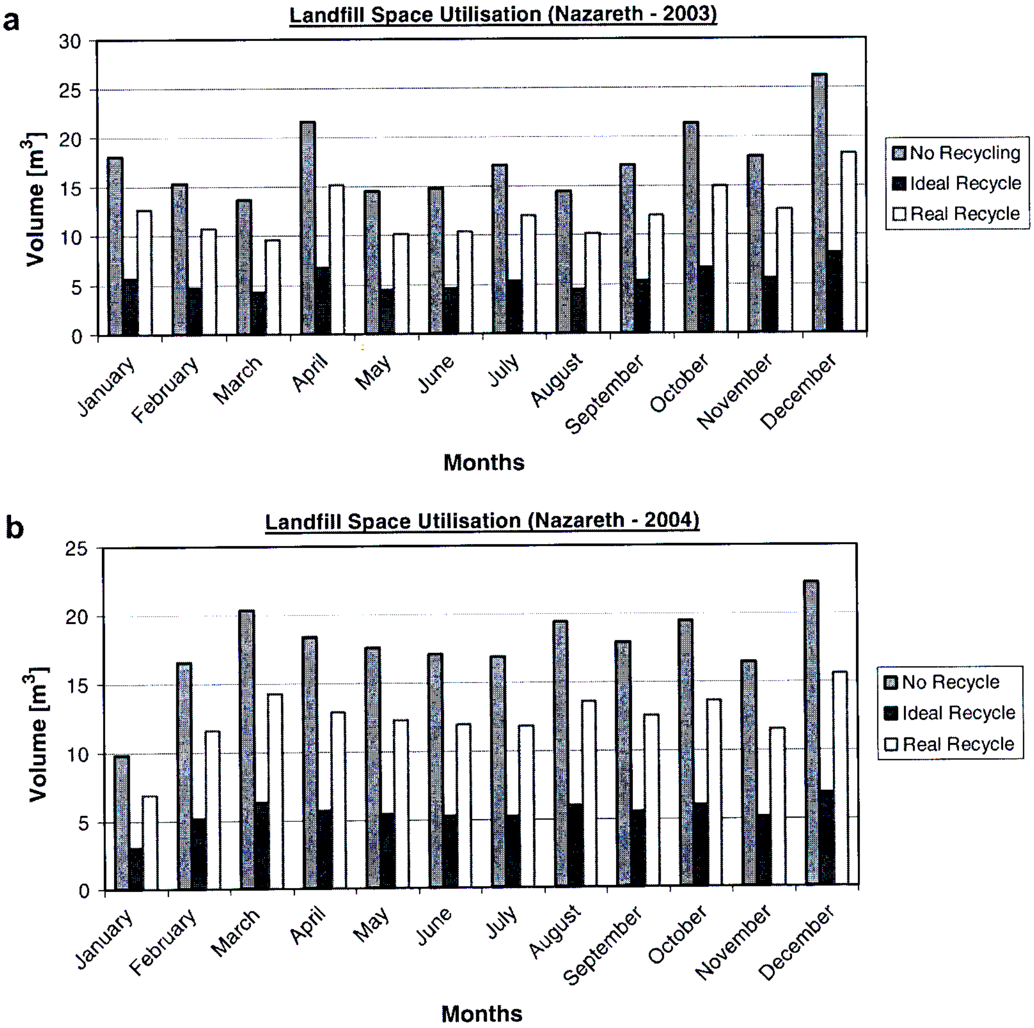

Fig. 9a–b. Landfill space utilisation Nazareth (2003–2004).

Table 3
Average selling prices for recyclables in Durban (2001–2005)

Commodity	Price (US$/ton)								
	2001	2002	2003	2004	2005	Mean	Min.	SD	Co. of variation
Cardboard	37	44	52	66	22	44	22	16	0.37
Magazines + newspaper	15	22	29	29	7	21	7	10	0.47
Computer paper	88	96	96	118	15	83	15	40	0.48
Low density plastic	74	88	96	118	118	99	74	19	0.19
High density plastic	No market for HDP in Durban				74	74	74	–	–
Ferrous metals	44	52	59	74	111	68	44	26	0.39
Glass	7	15	15	15	15	13	7	3	0.25

Source: Mgingqizana (2006).

fluctuations. Table 4 shows the prices for recyclables at the Westmead Recycling Centre, which have been used to calculate the expected income that could be generated by the waste minimisation scheme through the sale of recyclables. They are a record of the lowest and highest prices for a given recyclable for the year of analysis. The set of the low prices has been used to calculate the least expected revenue that could be generated from the sale of recyclables. This is termed the low profit scenario in the cost–benefit analysis. The high profit scenario in turn, uses the set of high prices to calculate the highest expected revenue from the sale of recyclables. It is important to note that the expected profit range could be exceeded at both ends given the price fluctuations shown in Table 4. Thus the expected revenue in each scenario could differ by 50% at most depending on the direction in which the commodity prices fluctuate. The spot commodity prices for the Westmead Recycling Centre shown in Table 5 are evidence of this behaviour. A typical CBA calculation is given in Table 6, while the overall results of the CBA for the ideal and realistic models are summarised in Tables 7 and 8, respectively. Both the high profit and low profit scenarios investigated in each model show that the proposed scheme will be economically viable. Note that the CBA does not include the cost of implementing educational campaigns to introduce Zero Waste into the case study communities. Net benefit/cost of capital ratios for each model also indicate that the scheme will be economically viable, subject to the constraints already mentioned.

The results show that environmental and economic benefits will be gained due to application of the proposed scheme. Environmental benefits are shown in the volume of air-space that could be saved due to the non-disposal of waste at the Mariannhill landfill. Economic benefits arise from the sale of recyclables, resulting in revenue from the scheme, and lower operating costs due to less waste being disposed at the landfill. It is important to note that Ideal cost savings could be achieved with the application of at-source separation by households. Given the expected benefits of the scheme, it is recommended that implementation at the pilot scale should be undertaken and possibly extended to the larger community served by the Mariannhill landfill site.

Table 4
Commodity selling prices for recyclables at Westmead Recycling Centre (2003–2004)

Commodity	Price (US$/ton)			
	2003		2004	
Cardboard	Low	High	Low	High
Magazines + newspaper	52	59	22	66
Computer paper	29	29	15	29
Low density plastic	96	103	15	118
High density plastic	88	88	118	147
Ferrous metals	52	52	74	74
Glass	7	15	7	7

Source: Mgingqizana (2006).

Table 5
Spot buying prices at Westmead Recycling Centre (15 March 2005)

Material	Price (US$/ton)	
	Normal grade	Sub-grade
Cardboard	22	
Paper	59	37
Copper	1032	811
Brass	737	369
Mild steel	22	22
Stainless steel	59	
Aluminium	737	221
Plastic (wrap)	7	
Plastic (PET)	29	
Plastic (colour)	103	
Plastic (milk)	29	
Glass	7	

Source: Ngcobo (2005).

Table 6
Cost–benefit analysis for 2003 (ideal model – high profit)

	Quantity	Rate	Amount
Disposal			
Collection	1176 tons	$29.50/ton	$34,703
Disposal			
Capital	980 m^3	$4.03/$m^3$	$3955
Operational	980 m^3	$5.54/$m^3$	$5429
Benefits			
Weighbridge	1176 tons	$16.22/ton	−$19,087
			$25,000
Minimisation			
Collection	1176 tons	$29.50/ton	$34,703
Scheme			
Capital			$4425
Operational	664 tons	$5.05/ton	$3353
Disposal			
Capital	427 m^3	$4.03/$m^3$	$1722
Operational	427 m^3	$5.54/$m^3$	$2364
Benefits			
Sale			−$47,362
Weighbridge	512 tons	$16.22/ton	−$8310
			−$9052
Total savings (Ideal)			$34,106

4. Conclusions

The communities of Mariannhill Park and Nazareth have been used as a case study for the introduction of a Zero Waste scheme into an already existing integrated waste management system. A CBA showed that the project will be worthwhile economically. Environmental benefits in terms of landfill space savings will also be achieved by the introduction of a waste minimisation scheme incorporating both communities.

A Zero Waste model, for use within similar realities in emerging countries, has been developed for post-consumer waste in urban areas with differing levels of service. Waste minimisation and recycling have been identified as necessary steps for the success of the model. Waste minimisation at point of purchase and reuse of waste within the household constitute the first step in the application of the model. The waste that arises after minimisation would then be recycled. Recycling using at-source separation or a wet/dry model constitutes the second step in the model. A correct application of this model, including implementation costs that were neglected in this study, could lead to achieving "Zero Waste" in the short term. However, paper and plastic will need disposal in the long term, given that they can only be recycled a finite number of times.

The case study discussed in this paper shows that Zero Waste models can be applied within existing waste management systems in South Africa. However, the success of such schemes will depend on the participation rate of households. Waste collection services in the Durban area are well established. In the drive towards Zero Waste, a positive attitude

Table 7
Summary of results for recycling scheme – high profit scenario

	Mariannhill Park		Nazareth		Total	
	Ideal	Realistic	Ideal	Realistic	Ideal	Realistic
Total MSW (tons)	1916	1916	510	510	2426	2426
Volume (m^3)	1597	1597	425	425	2022	2022
Disposed MSW (tons)	900	1341	158	357	1058	1698
Volume (m^3)	750	1118	132	298	882	1415
Total Recyclables (tons)	1015	575	352	153	1367	726
Hard plastic (tons)	134	76	31	13	165	892
Soft plastics (tons)	326	184	1271	55	453	240
Glass (tons)	153	87	36	16	189	102
Tin/aluminium (tons)	134	76	31	13	165	89
Cardboard (tons)	96	54	611	27	157	81
Paper (tons)	172	96	66	29	239	126
Revenue (recyclable)	$83,949	$47,517	$30,762	$13,375	$114,711	$60,801
Air space savings (m^3)	847	479	293	127	1140	607
CBA – total benefit					$84,444	$40,546
Mass cost savings ($/ton)					34.81	16.71
Volume cost savings ($/$m^3$)					41.76	20.05

Table 8
Summary of results for recycling scheme – low profit scenario

	Mariannhill Park		Nazareth		Total	
	Ideal	Realistic	Ideal	Realistic	Ideal	Realistic
Total MSW (tons)	1916	1916	510	510	2426	2426
Volume (m^3)	1597	1597	425	425	2022	2022
Disposed MSW (tons)	900	1341	158	357	1058	1698
Volume (m^3)	750	1118	132	298	882	1415
Total recyclables (tons)	1015	575	352	153	1367	726
Hard plastic (tons)	134	76	31	13	165	892
Soft plastics (tons)	326	184	1271	55	453	240
Glass (tons)	153	87	36	16	189	102
Tin/aluminium (tons)	134	76	31	13	165	89
Cardboard (tons)	96	54	611	27	157	81
Paper (tons)	172	96	66	29	239	126
Revenue (recyclable)	$60,528	$34,261	$21,308	$8,578	$81,836	$42,840
Air space savings (m^3)	847	479	293	127	1140	607
CBA – total benefit					$51,571	$22,493
Mass cost savings ($/ton)					21.26	9.27
Volume cost savings ($/$m^3$)					25.50	11.12

towards waste minimisation and recycling must be instilled among residents. The results of the questionnaire suggest that residents in Mariannhill Park and Nazareth are willing to recycle their household waste, but their willingness to minimise waste has not been clearly established. The response of householders to specific attitude-studies would yield the determinants for designing ad hoc waste minimisation strategies. Educational campaigns can then be designed to reinforce a more positive attitude among householders, taking cognisance of income levels, educational background, language and the nature of their waste stream.

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C2: Conference Publications

C.2.1 Proceedings of the Biennial Congress of the Institute of Waste Management of Southern Africa, WasteCon 2006, Somerset West, South Africa: IWMSA

INTRODUCING ZERO WASTE IN SOUTH AFRICA: COMPARISONS BETWEEN URBAN AND RURAL AREAS

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Abstract

The South African Department of Environmental Affairs and Tourism (DEAT) recently introduced the concept of waste hierarchy (Reduce – Reuse – Recover – Dispose) into environmental legislation, as the only possible road towards sustainable development (National Environmental Management Act No. 107 of 1998). It is within the waste hierarchy that ZERO WASTE emerges as a tool to integrate waste reduction, reuse and recovery (recycling). ZERO WASTE is a new planning approach that maximises recycling and minimises waste, and is, at the same time, a design principle that ensures that products are made to be reused, repaired or recycled back into nature or the market place. Communities have been identified in rural and urban areas to study the applicability of waste minimisation schemes in the move towards ZERO WASTE. The study reveals that rural areas lack basic waste collection and disposal systems. This lack in service delivery prevents the full implementation of waste minimisation schemes into these areas and hence introduction of ZERO WASTE. Urban communities, on the other hand, are already served by established waste management systems, therefore facilitating full implementation of ZERO WASTE schemes.

Keywords: Rural communities, Urban communities, Municipal solid waste, Waste minimisation, Recycling, ZERO WASTE

1. Introduction

The research undertaken in this paper is in anticipation of the fulfilment of the goals of the Polokwane Declaration on Waste Management (DEAT, 2001), which has set as its target the reduction of waste generation and disposal by 50% and 25% respectively by 2012 and the development of a plan for ZERO WASTE by 2022.

In order to address the above scenario, waste minimisation plans, which maximise recycling, have to be developed and adopted into existing waste management systems. Currently, recycling plays a vital role in waste reduction and has the distinct advantage of creating labour intensive employment. Maximising recycling to promote waste minimisation after consumption is the focus of this paper. Experience suggests that recycling alone cannot effectively reduce the amount of waste that is being generated, but other waste minimisation tools need to be implemented. This is the principle behind the adoption of the goals stated by the Polokwane Declaration (DEAT, 2001). The objectives of the research are:

- To investigate ZERO WASTE in rural and urban areas through application of a waste minimisation scheme

- To compare the applicability of ZERO WASTE models in rural and urban areas

The research focuses on municipal solid waste with particular emphasis on recyclable fractions.

1.1 Waste management in South Africa

The organisation and planning of public waste collection services in developing countries is very rudimentary (Buenrostro and Bocco, 2003). Provision of waste collection services is predominantly in urban areas, while it ranges from poor to non-existent in informal urban settlements and rural areas. This disparity in service provision between the different areas is not the only problem experienced in waste management services in developing countries. Other problems include a highly inefficient waste collection services with variable levels of service; lack of environmental control systems; inadequate municipal services due to limited resources; indiscriminate dumping and littering and; a public with little or no awareness of waste management practices (Onu, 2000).

Although the preceding discussion describes waste management in developing countries not all of the above problems are experienced in South Africa. South Africa has features of both developed and developing nations in relation to waste management. Urban areas have distinct features of developed nations. These include: increasing use of sophisticated technology; emphasis on waste minimisation and recycling; greater responsibility and participation by householders in the waste management process; ever more stringent legislation on all aspects of the waste management process and; a regular and efficient domestic waste collection system (Water Research Commission, 1996). Conversely, informal urban settlements and rural areas have features which are characteristic of waste management systems in developing countries. This include: increasing need for community participation in the waste management process; extensive recovery, reuse and recycling of wastes and; the achievement of economic empowerment through the involvement with wastes (WRC, 1996).

1.2 ZERO WASTE

Different waste management options can be ranked into a hierarchy giving a wide scope of their relative importance within waste management (Robinson, 1996). It is within the waste hierarchy that waste minimisation emerges as a tool to integrate waste reduction, reuse and recovery (recycling). Whereas waste minimisation focuses on reducing the amount of waste generated, the concept of ZERO WASTE goes further. ZERO WASTE maximises recycling, minimises waste through a reduction in consumption and ensures that products are made to be reused, repaired or recycled back into nature or the market place (Grass Roots Recycling Network, 2004).

The main steps required for achieving ZERO WASTE are as follows:

1. Waste minimisation
    a. Reduction of waste at point of purchase
    b. Reuse of waste products within the house
2. At-source separation of waste
    a. Purtriscibles/wet waste stored in one bag
    b. Recyclables/dry waste stored in another bag
3. Central separation, sorting and storage of recyclables at a central point
4. Transportation of recyclables to nearest buy back centre
5. Education
    a. Running start-up educational campaigns specifically designed to encourage waste minimisation behaviour among households.

   b. Running educational campaigns to encourage on-going awareness of the ZERO WASTE scheme implemented in the area
6. Recycled Products
   a. Types of recycled products made by converters
   b. Assess which of these products could be bought by households
   c. Encourage households to buy this products
7. Public participation survey by use of questionnaire to assess the attitudes of householders towards application of the proposed ZERO WASTE scheme in their area and implementation of the scheme based on the results of the survey
8. Assessment of an institutional framework, administrative and financial, within the responsible Municipality to implement a ZERO WASTE scheme.

1.3 The Case Study Areas

To realise the objectives of the research, two case studies were selected to investigate the differences between rural and urban areas with respect to service delivery, income levels and availability of an existing waste management systems. Ndumo, situated in northern KwaZulu-Natal, is typical of a rural area with no waste management system in place. Durban is typical of an urban area with a well established integrated waste management system. In Durban, two communities, adjacent to the Mariannhill Landfill site were used as a case study. The Mariannhill Park community represents a middle income area and Nazareth represents a low income area. The waste generated in these two areas is disposed of at Mariannhill landfill; hence the impact of waste minimisation in these two areas on landfill volumes at Mariannhill landfill could be readily assessed.

2. Proposed Waste minimisation scheme

2.1 Ndumo

To develop the waste minimisation scheme, the following steps were carried out:

1. A series of field trips were conducted between March and October 2004 in order to assess the waste project that was already operational in Ndumo. The assessment included the facilities provided; a measurement of the quantity of recyclables generated by the project and; identification of the major waste generators within Ndumo.
2. An End-life cycle assessment for the recyclables was carried out to identify suitable recyclers/converters/buyers for the recyclables within the proximity of Ndumo.
3. Following information collection, a ZERO WASTE scheme was proposed for Ndumo. Given the recyclable quantities generated in the existing waste management process, an assessment was made to check whether the proposed was sustainable. The criteria used in the assessment were: income that could be generated by the sale of recyclables; transportation costs and utilisation of the waste facilities already provided by an existing waste project funded by the PEACE Foundation as part of a "Sustainable Living and Poverty Alleviation Project (DEAT, 2004).
4. A recommendation was put forward to the waste project proponents for the use of the waste project facilities in Ndumo for separating, sorting and storing the recyclables.
5. An attitude survey was to be conducted by means of a questionnaire to assess the attitudes of householders towards the proposed scheme.

2.2 Durban

To develop the waste minimisation scheme, the following steps were carried out:

1. The waste arising from two areas, namely Mariannhill Park, a middle-income area and Nazareth, a low-income area, was analysed. The analysis period was two years, 2003 and 2004. Waste data from these areas was collected and a waste stream analysis

carried out to determine the yield of recyclable fractions from the collected waste. Waste generation information was sourced from DSW.

2. An End-life cycle assessment for the recyclables was carried out to identify suitable recyclers/converters/buyers for the recyclables in the Durban Metro area. The Westmead community-recycling centre located approximately 4-6 km from Mariannhill Park and Nazareth was used to conduct the assessment.
3. Following information collection and data processing from the study areas, a waste minimisation scheme was proposed for the two areas. A Cost benefit analysis was carried out to assess the economical benefits of the proposed scheme as compared with the conventional collection and disposal of solid domestic waste. The CBA focused on landfill cost savings and landfill space saving due to the non-disposal of waste at the landfill. The CBA also considered the income that could be generated from the sale of the recyclables to suitable buyers.
4. A recommendation was put forward to DSW for the use of the transfer station at the Mariannhill Landfill in the ZERO WASTE scheme.
5. An attitude survey was to be conducted by means of a questionnaire to assess the attitudes of householders towards the proposed scheme.

3 Application of Waste minimisation scheme

3.1 Ndumo

Waste is collected from around Ndumo by means of waste bins located at strategic places in the area. However, no waste collection system is available for households in the area. Collection is carried by members of the community who were trained in waste collection and waste type identification, costing of waste, alternative uses of waste, compost making methods, basic business skills and health and safety. The bulk of the waste though was to come from the major waste generators in the area, which include the local supermarket, an Army base, the Police and the Ndumo nature reserve. For the period of this research, only the Army was delivering waste to the facilities provided by PEACE.

Facilities provided for the PEACE project include a waste shed (see Figure 3.1), where separation and storage of recyclables is carried out. Non-recyclables are burnt in an incinerator (see Figure 3.2). The recyclables are separated according to type, with some fractions being separated by colour: especially glass, plastics and cans. For the 14 months for which the project was assessed, the amount of recyclables collected is shown in Table 3.1. The potential income that could be generated from the sale of the recyclables was also calculated using prices provided by Green et al (2004). These are also shown in Table 3.1.

Figure 3.1 Waste separation, sorting and storage shed in Ndumo

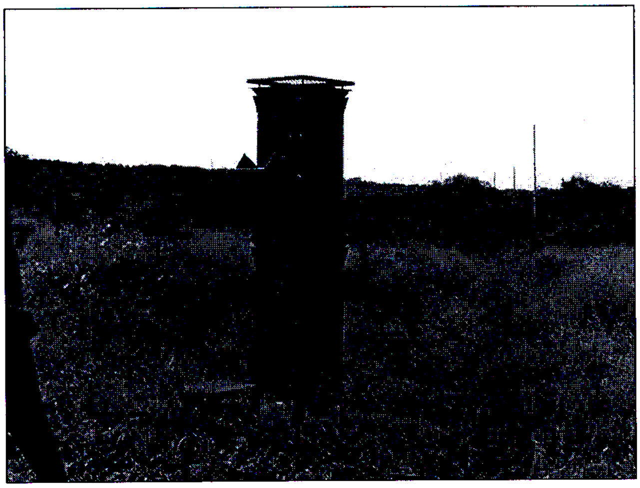

Figure 3.2 Incinerator for non-recyclables in Ndumo

Table 3.1 Mass of recyclables and potential income generation from waste at Ndumo

Material	Mass (kg)	Value (R/kg)	Potential Income (R)
Food cans	150	0.15	22.50
Glass bottles	440	0.20	88.00
Plastic - Bottles	100	0.05	5.00
- Packaging	35	0.05	1.75
Cardboard	100	0.45	45.00
Cans - Loose	10	0.65	6.50
- Compacted	310	0.65	201.50
		Total	**370.25**

The End-life Cycle Assessment showed that the recyclable in Ndumo were to be transported and sold at the Jozini Recycling Centre located approximately 70 km from the source. The major recyclers collecting material for the Centre were also identified. However, when this research was conducted, the recyclers were not collecting recyclables from the centre. The sale of recyclable was on hold while an institutional framework for the project was being set up (Green et al, 2004). As such, the final destination for the processing of the recyclables could not be determined.

The income that could be generated from the sale of recyclables could not cover the monthly costs of running the project. External finances have to be sourced from donor agencies to cover the wages of the workers, which amount to R4000 per month (PEACE, 2004). Another problem is the transportation costs of recyclables to the Jozini Recycling Centre. The transportation of recyclables was also found to be inefficient, as a roundtrip of 140 km (70 km each way) is required. Depending on the type of vehicle used, relevant transportation rates vary between (R346 – R410) for each trip. The cost of one trip would use up the total potential income that could be generated from the sale of recyclables accumulated in Ndumo at present. This point further highlights the need for external funding of the project or the active participation of the Jozini Municipality in funding the project. Therefore, it is clear that the Ndumo waste project cannot sustain itself financially based solely on the sale of recyclables collected at the Jozini Centre.

In terms of operational efficiency, the waste facilities at Ndumo are sustainable in the long term given current rates of waste generation and utilisation by waste generators. As long as the recyclables are taken off-site regularly, there will be no problem in terms of availability of space. The possibility of over-utilisation can arise when all the major waste generators use the facilities at the same time. Careful planning and monitoring will be necessary to make sure that such a situation does not arise. A simple solution would be the drawing up of a schedule as to when the major waste generators could deliver their waste to the centre.

3.2 Durban

Mariannhill Park is a formal, medium income area with a high level of service. The number of dwellings is 3000 units approximately (Marshall, 2005). Using the average of 4.5 people per dwelling (Stats SA, 2001) the population is approximated at 13 500 people. Waste collection is carried out once a week by Durban Solid Waste. On average, 80 tons/month of MSW is collected from Mariannhill Park. Nazareth is a semi-formal, low income area with a medium level of service. The number of dwellings is estimated at 980 – 1000 (Marshall, 2005). Using the average of 4.5 people per dwelling (Stats SA, 2001) the population is approximated at 4410 - 4500 people. Waste collection is carried out once a week by a contractor appointed by DSW. Over 21 tons/month of MSW is collected in Nazareth. Waste generation figures for Mariannhill Park and Nazareth are shown in Figure 3.3.

The ZERO WASTE scheme proposed for these communities is based on existing recycling strategies around South Africa. It is a combination of three systems: drop-off, kerbside and central sorting. It takes cognisance of the advantages and disadvantages of each system, current waste collection methods in the two areas and minimisation of changes required on the part of households. The scheme is also based on a Wet/Dry model for separation of waste at-source. This means that the waste would be separated into wet and dry fractions by households. Different coloured bags would be provided for collection of each fraction; black bags for disposable (purtriscible, wet waste) and any other colour for recyclables (dry waste). The two fractions would not be allowed to mix as in current waste collection methods.

The final results of the analysis of the proposed scheme are shown in Table 3.2 and 3.3, with recycling commodity prices used in the calculations shown in Table 3.4. The results show that environmental and economical benefits will be gained due to application of the proposed scheme over the two-year analysis period. Environmental benefits are shown in the volume of air-space that could be saved due to the non-disposal of waste at the Mariannhill landfill. The ideal model sets the upper bound for landfill space saving that could be expected for the proposed scheme. The real model gives an average landfill space saving that could be expected for the proposed scheme without the use of at-source separation of the recyclables. Economic benefits arise from the sale of recyclables, resulting in revenue from the scheme, and lower operating costs due to less waste being disposed at the landfill. It is important to note that Ideal cost savings could be achieved with the application of at-source separation by households. Also, the expected profit range could be exceeded at both ends given the variation of the prices shown in Table 3.4. Thus the expected revenue in each scenario could differ by 50% at most depending on the direction in which the commodity prices fluctuate.

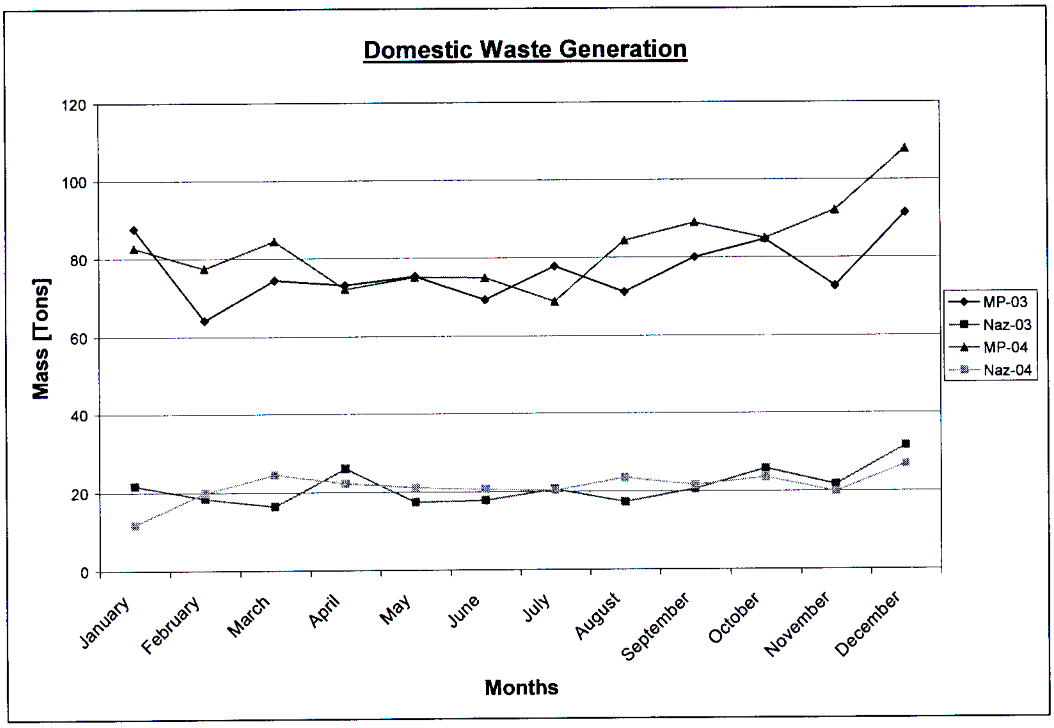

Figure 3.3 Domestic waste generated in Mariannhill Park and Nazareth (2003 – 2004) (Source: DSW (Marshall 2005))

Table 3.2 Summary of results for Waste Minimisation Scheme – High profit scenario

	Mariannhill Park		**Nazareth**		**Total**	
	Ideal	**Real**	**Ideal**	**Real**	**Ideal**	**Real**
Total MSW (Tons)	1916	1916	510	510	2426	2426
Volume (m^3)	1597	1597	425	425	2022	2022
Disposed MSW (Tons)	900	1341	158	357	1058	1698
Volume (m^3)	750	1118	132	298	882	1415
Total Recyclables (Tons)	**1015**	**575**	**352**	**153**	**1367**	**726**
Hard Plastic (tons)	134	76	31	13	165	892
Soft Plastics (tons)	326	184	1271	55	453	240
Glass (tons)	153	87	36	16	189	102
Tin/Aluminium (tons)	134	76	31	13	165	89
Cardboard (tons)	96	54	611	27	157	81
Paper (tons)	172	96	66	29	239	126
Revenue (Recyclable)	**R569,175**	**R322,164**	**R208,564**	**R90,680**	**R777,739**	**R412,284**
Air Space Saving (m^3)	**847**	**479**	**293**	**127**	**1140**	**607**
CBA - Total Benefit					**R572,527**	**R274,901**
Mass Cost Saving (R/ton)					**236.00**	**113.31**
Volume Cost Saving (R/ m^3)					**283.14**	**135.95**

Table 3.3 Summary of results for Waste Minimisation Scheme – Low profit scenario

	Mariannhill Park		Nazareth		Total	
	Ideal	Real	Ideal	Real	Ideal	Real
Disposed MSW (Tons)	1916	1916	510	510	2426	2426
Volume (m^3)	1597	1597	425	425	2022	2022
Disposed MSW (Tons)	900	1341	158	357	1058	1698
Volume (m^3)	750	1118	132	298	882	1415
Total Recyclables (Tons)	1015	575	352	153	1367	726
Hard Plastic (tons)	134	76	31	13	165	892
Soft Plastics (tons)	326	184	1271	55	453	240
Glass (tons)	153	87	36	16	189	102
Tin/Aluminium (tons)	134	76	31	13	165	89
Cardboard (tons)	96	54	611	27	157	81
Paper (tons)	172	96	66	29	239	126
Revenue (Recyclables)	**R410,378**	**R232,290**	**R144,469**	**R58,162**	**R554,847**	**R290,452**
Air Space Saving (m^3)	**847**	**479**	**293**	**127**	**1140**	**607**
CBA - Total Benefit					**R349,653**	**R152,504**
Mass Cost Saving (R/ton)					**144.13**	**62.86**
Volume Saving (R/ m^3)					**172.92**	**75.42**

Table 3.4 Commodity prices for recyclables at Westmead Recycling Centre (2003 - 2004)

Commodity	**2003**		**2004**	
Cardboard	**Low**	**High**	**Low**	**High**
Magazines + Newspaper	0.35	0.40	0.15	0.45
Computer paper	0.20	0.20	0.10	0.20
Low Density Plastic	0.65	0.70	0.10	0.80
High Density Plastic	0.60	0.60	0.80	1.00
Ferrous metals	0.35	0.35	0.50	0.50
Glass	0.05	0.10	0.05	0.05

4 Discussion

Ndumo is a rural area where an existing waste management project has been assessed. A waste minimisation scheme has been proposed for the area. Although the scheme can benefit the community, it faces a number of problems. Waste collection services were not being provided to households in the existing waste project, therefore the waste minimisation scheme will need to address this problem. Furthermore, the recyclable material yields are very low due to lack of support by the major waste generators in the area. This in turn renders the project financially unsustainable as income generation from the sale of recyclables cannot cover the maintenance costs of the project. These maintenance costs include the wages of the workers and transportation costs to the Jozini Recycling Centre.

Finally, the Jozini Municipality does not have the administrative and financial capacity to take over and administer the project.

The rural case study presented in this paper is typical of poverty relief projects funded by DEAT. An assessment of these projects shows that most of them are financially unsustainable (DEAT, 2005). This means that once the funding from DEAT ceases, the projects cannot continue. Donor funding is required to continue the projects. In the specific instance of waste projects in rural areas, where unemployment and poverty are on the increase, households in these areas are unable to pay for basic services such as waste collection and disposal. And although municipalities have plans in place to provide these services, financial constraints make it almost impossible to do so. Even when pilot projects have been started by NGOs, municipalities still experience difficulties in assuming responsibility for the continuation of the projects. The problems experienced in small rural communities are not unique to any country, but are in many instances common for all developing countries (Otto et al, 2002). Otto et el (2002) further point out that financial constraints are in many instances one of the main stumbling blocks to the delivery of environmentally sound waste management services.

The communities of Mariannhill Park and Nazareth, in Durban, have been used as a case study for the introduction of a waste minimisation scheme into an already existing integrated waste management system. A CBA conducted for the waste minimisation scheme has shown that the scheme will be worthwhile economically. Environmental benefits in terms of landfill space savings will also be achieved by the introduction of a waste minimisation scheme for both communities. It is hypothesised that within the Mariannhill Park community, existing recycling attitudes will have to be overcome in the implementation of at-source separation. These recycling attitudes may not as entrenched in Nazareth as they are in Mariannhill Park. Waste minimisation, may, on the other hand represent a new concept altogether in both communities. The validity of these hypotheses will need to be tested by the use of questionnaires for both communities.

The urban case study presented in this paper is typical of waste management systems currently in operation within metropolitan municipalities, with specific regard to formal settlements. Households within these areas are able to pay for waste collection and disposal services. The municipalities in turn have the administrative and financial capacity to provide the required services.

Comparison between rural and urban areas shows that application of ZERO WASTE schemes is easier in urban areas than in rural areas. Recycling output of rural areas is so low that the sale of the quantities generated cannot cover the cost associated with managing the scheme, even when collection, separation, sorting and storage facilities have provided. Recycling output in urban areas, which can be maximised by application of at-source separation, is such that financial savings can be achieved when waste minimisation schemes are applied. The financial savings accrue as a result of the lower quantities of MSW being disposed of at a landfill and the sale of the recyclables. Although the commodity prices for recyclables are volatile, the urban case study shows that financial savings can still be achieved by application of a waste minimisation scheme. The lack of institutional capacity by rural municipalities as compared to their urban counterparts also hinders the application of waste minimisation schemes in rural areas.

5 Conclusions

In this paper, the application of a waste minimisation scheme for a rural area has been investigated. It has been shown that the rural area does not generate enough recyclable material to cover the maintenance costs associated with application of the scheme. Other problems include lack of support by major waste generators in the area and lack of administrative and financial capacity by the responsible municipality to apply the proposed scheme. Application of a waste minimisation scheme to an urban area has shown that financial savings can be achieved in the implementation of the proposed scheme. Other benefits include landfill space savings arising from the disposal of less waste at the landfill. In comparing the case study areas, rural areas lag behind urban areas in the application of waste minimisation schemes. Lack of administrative and financial support by the responsible municipalities and lack of integrated waste management systems are the main constraints that account for this lag. Since waste minimisation schemes form an initial entry point into ZERO WASTE models, these constraints will have to be overcome before ZERO WASTE management schemes can be applied to rural areas. Comparatively, urban areas do not experience these constraints; hence application of the ZERO WASTE management schemes can be implemented in urban areas.

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ZERO WASTE STRATEGIES FOR URBAN AREAS IN SOUTH AFRICA

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SUMMARY: ZERO WASTE is a design principle that ensures that products are made to be recycled back into nature or the market place. Two peri-urban communities have been identified in Durban to study the applicability of an integrated ZERO WASTE model with respect to service delivery, income levels and availability of an existing waste management system. The Durban experience was used to develop a waste minimisation model for post-consumer waste for the Durban Municipality that was then compared with similar models designed for Johannesburg and Cape Town. These models calculate the optimal flow rates of various waste streams which give the minimum overall operational cost of the waste management systems over the next 25 years. The results show that, particularly in the case of Cape Town and Durban, it is favourable to subsidise private material recovery facilities (MRF) or to implement publicly-run MRF than to send recyclables to landfill.

1. INRODUCTION

Solid waste management in developing countries is characterised by highly inefficient waste collection practices, inadequate levels of service, limited resources, lack of environmental control systems, indiscriminate dumping, littering and scavenging and a poor environmental and waste awareness of the general public (Onu, 2000). South Africa, as other emerging countries, is striving towards meeting international standards by applying advanced concepts such as the waste hierarchy and zero waste to their environmental policies.

In 2001, the Polokwane Declaration on Waste Management (DEAT, 2001) set its target to the reduction of waste generation and disposal by 50% and 25% respectively by 2012 and the development of a plan for ZERO WASTE by 2022. ZERO WASTE is a planning concept that maximises recycling and minimises waste, and a design principle that ensures that products are made to be reused, repaired or recycled. The main aim of a ZERO WASTE scheme is to assess the nature of the waste and its recycling potential so to extend its usage-life, and so reducing wastage.

Most of the recycling in South Africa is conducted by the packaging industry, through private entrepreneurs and agents (DEAT, 1999).
Other methods of recycling, that include organized scavenging, drop-off and buy-back centres take place on landfill sites or transfer stations and achieve less than 1% reduction in the waste stream (des Ligneris, 2000; Ridl, 2003).

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This paper describes the preliminary steps towards the optimisation of Waste Minimisation/ZERO WASTE strategy into an already established integrated waste management system and the development of a ZERO WASTE model for post-consumer domestic waste in urban communities in South Africa. Two communities, adjacent to the Mariannhill Landfill site in Durban, were used as a case study. The Mariannhill Park community represents a middle income area and Nazareth represents a low income area. The waste generated in these two areas is disposed at the Mariannhill sanitary landfill; hence the direct impact of waste minimisation on landfill volumes and financial savings could be readily assessed.

The Durban community experience was used to develop a city-wide waste minimisation model that was then compared with similar schemes developed for Johannesburg and Cape Town .

2. METHODOLOGICAL APPROACH

Mariannhill Park and Nazareth are two communities located adjacent to the Mariannhill General Waste Landfill site about 20km west of the Durban CBD (Central Business District). The area forms part of the Inner West Region of the eThekwini Municipality, which comprises 11.2% of the total area of the municipality, with a population size of 631 705 inhabitants (20.6% of the total municipal population). Households in these areas are sub-divided into formal and informal, with 74% of residents living in formal housing that produce 95% of the domestic waste (SKC, 2002).

An End-Life Cycle Assessment, for 2003 and 2004, was carried out for the recyclable fractions in the waste stream from the two communities, which include paper (high grade white paper and cardboard), plastic (PET, HDPE and LDPE), glass and cans. The nearby Westmead Community Recycling Centre was used to determine the commodity prices for the recyclable fractions. A preliminary waste minimisation scheme was proposed with the main aim of demonstrating the benefits that arise from application of waste minimisation. A Cost Benefit Analysis (CBA) was carried out to assess the economical benefits of the proposed waste minimisation scheme as compared to conventional collection and disposal of solid waste. The CBA focuses on landfill cost and landfill space savings, and it also considers the income that could be generated from the sale of the recyclables to suitable buyers. Table 1 presents the main features of the two studied communities, as well as the percentage by mass of recyclables. Table 2 shows the fluctuation in 5 years recorded prices for recyclables in Durban.

The current recycling output from Mariannhill Park averages around 19 tons/month and 3.5 tons/month from Nazareth. Based on the recyclable yields, a waste minimisation scheme was proposed for the two communities. It is a combination of three systems: drop-off, kerbside and central sorting. The scheme is based on a Wet/Dry model or at-source separation. Different coloured bags would be provided for collection of each fraction; black bags for disposable (putrescible, wet waste) and any other colour for recyclables (dry waste). The two fractions would not be allowed to mix as in current waste collection methods. For both Mariannhill Park and Nazareth, separate curb-side collection of both fractions would be undertaken. Recyclables would be taken to the existing Mariannhill Transfer station for separation, sorting and storage.

The recyclables would be separated manually into cans, glass, paper and plastics. Each category would then be sorted according to grade and then stored in a skip awaiting removal by a designated recycling company.

Table 1. Main characteristics of the Durban studied areas.

FEATURES	MARIANNHILL PARK	NAZARETH
Income (Source: World Bank)	55% lower middle income 45% upper middle income	70% lower income 30% lower middle income
No. Dwellings	3000	980 – 1000
Population	13500	4410 - 4500
Waste Production (SKC, 2002)	0.20 kg/person/day	0.16 kg/person/day
Waste Collection	Waste collection is carried out once a week by the municipal waste disposal unit (Durban Solid Waste-DSW).	Waste collection is carried out once a week by a contractor appointed by DSW.
Type of service	The service is door-to-door, with each dwelling supplied with 2 x 85 litre black plastic bags a week.	The service is door-to-door, with each dwelling supplied with 2 x 85 litre black plastic bags a week.
RECYCLABLES	(% BY MASS)	(% BY MASS)
Hard plastics	7	6
Soft plastics	17	25
Glass	8	7
Cans (Tin/Aluminium)	7	6
Cardboard	5	12
Other Paper	9	13
Total	53	69

Table 2. Average selling prices for recyclables in Durban (2001 – 2005).

	Price [US$/ton]								
Commodity	**2001**	**2002**	**2003**	**2004**	**2005**	**Mean**	**Min.**	**Std. Dev.**	**Co. of Variation**
Cardboard	37	44	52	66	22	44	22	16	0.37
Magazines + Newspaper	15	22	29	29	7	21	7	10	0.47
Computer paper	88	96	96	118	15	83	15	40	0.48
Low Density Plastic	74	88	96	118	118	99	74	19	0.19
High Density Plastic	No market for HDP in Durban				74	74	74	-	-
Ferrous metals	44	52	59	74	111	68	44	26	0.39
Glass	7	15	15	15	15	13	7	3	0.25

Table 3. Results of the Waste Minimisation scheme for the Mariannhill Case Study.

	High Profit Scenario			Low Profit Scenario		
	Mariannhill Park	**Nazareth**	**Total**	**Mariannhill Park**	**Nazareth**	**Total**
Total MSW (Tons)	1916	510	2426	1916	510	2426
Volume (m^3)	1597	425	2022	1597	425	2022
Disposed MSW (Tons)	1341	357	1698	1341	357	1698
Volume (m^3)	1118	298	1415	1118	298	1415
Total Recyclables (Tons)	575	153	726	575	153	726
Hard Plastic (tons)	76	13	892	76	13	892
Soft Plastics (tons)	184	55	240	184	55	240
Glass (tons)	87	16	102	87	16	102
Tin/Aluminium (tons)	76	13	89	76	13	89
Cardboard (tons)	54	27	81	54	27	81
Paper (tons)	96	29	126	96	29	126
Revenue (Recyclable)	$47,517	$13,375	$60,801	$34,261	$8,578	$42,840
Air Space Saving (m^3)	479	127	607	479	127	607
CBA - Total Benefit			$40,546			$22,493
Mass Cost Saving (US$/ton)			16.71			9.27
Volume Cost Saving (US$/ m^3)			20.05			11.12

For the city-wide Johannesburg, Cape Town and Durban, instead, a Waste Stream Analysis was carried out by developing waste flow diagrams for each city and then used to create separate waste stream models. The models were developed to simulate the Waste Stream and to predict its development over time. They work on the hypothesis that each particular stream (separate collected waste, transfer station waste, etc) of the MWMS concerned has a specific associated cost (defined as cost per ton of waste processed). The optimal flow rates of the various waste streams for the developed model which give the minimum overall operational cost (objective function) of the MWMS for future years were then calculated from 2005 to 2031. Waste recovered in the "recovery streams" (eg: the private recycling stream in the cases of Johannesburg and Cape Town or the publicly-run stream in the case of Durban) was given a landfill airspace credit value to account for the significant savings in landfill disposal costs.

3. RESULTS

3.1 The Mariannhill Case Study

The prediction-results of the application of the waste minimisation model in Durban are reported below in Tables 3, where a high profit scenario is compared with a low profit case, based on the analysis of the marked volatility from 2000 to 2005 [7].

On average, the Zero Waste scheme applied at Mariannhill Park contributes in saving 20m^3/month (30%) of landfill space for the years of study (2003-2004), which results in an actual saving of 16 – 27m^3 / month for both years. It can be derived that at least 16m^3/month of landfill space saving should be achieved by the proposed scheme. At Nazareth, the scheme would have saved 5m^3/month (28%) of landfill space for both 2003 and 2004. This results in an actual saving of 3–7m^3 / month for both years. Given that these savings fluctuate seasonally, at least 3m^3/month of landfill space saving should be achieved by the proposed scheme. The results from Table 4 show that environmental and economical benefits will be gained due to application of the proposed scheme. Environmental benefits are shown in the volume of air-space that could be saved due to the non-disposal of waste at the Mariannhill landfill. Economic benefits arise from the sale of recyclables, resulting in revenue from the scheme, and lower operating costs due to less waste being disposed at the landfill. Note that the CBA does not take into consideration costs related to running educational campaigns or transportation costs associated with the separated collections of the waste.

3.2 Johannesburg, Cape Town and Durban city-wide results

Figures 1 and 2 present the modeled optimum waste recovery rates from 2005 to 2030 for Johannesburg and Cape Town (Stotko and Trois, 2006) and from 2007 to 2032 for Durban (Douglas, 2007).

Figure 1 illustrates that according to the first developed model, it makes economic sense to increase the recovery of waste materials until a certain threshold value for both Cape Town and Johannesburg. The threshold value represents the point at which, under the proposed management system, all of the available material that is economically feasible to recover is depleted. This is consistent with the results of the second model for Durban in Figure 2. Although the recovery rate is higher than for the first model, the recommendation is the same – recovery of waste materials should increase until a threshold value. The recovery rate is higher since this model analyses incoming landfill waste as opposed to total city-wide generated waste and also factors in substantial composting.

The reason for the gradual decrease in the curve after 2027 is because the MRF input streams become saturated, *viz.* their input capacity is reached.

Figure 1 shows that in Cape Town, until the year 2010, it is more favourable to give extensive recycling subsidies (up to 100% subsidisation) to private recyclers than to send recyclable materials to landfill. This is due to the very few recycling initiatives in place, coupled with the fact that waste collection and disposal is becoming extensively more expensive. Both translate into the need to support existing private recycling initiatives until the Council has developed its own recovery infrastructure. Figure 2 shows that for Durban, the proposed scheme of the Municipality setting up on-site MRF will provide substantial benefit while maintaining financial viability.

It is interesting to note that the threshold value for Cape Town is 6% higher than that of Johannesburg, since collection and disposal costs for the Cape Town City Council are significantly higher than those of the Solid Waste Co-ordinators for Johannesburg, namely Pikitup. The waste collection costs for the Cape Town City Council is approximately 50

US$/tonne (Stotko and Trois, 2006) as compared to the same cost for Pikitup of 45US$/tonne (both values are reported for the year 2004/2005). The reason that the disposal costs in Cape Town are significantly higher than the same costs for landfill sites in Johannesburg lies in the fact that all of Cape Town's Landfill Sites are classified as requiring leachate collection systems (B^+), while only one of the Pikitup operated landfill sites in Johannesburg is a (B^+). Durban's landfills are the same as Cape Town's in this regard. The Cape Town City Council's waste collection costs are greater than those exhibited by Pikitup for the reason that Johannesburg has two more fully-functional centralised landfill sites than its Cape Town counterpart, which effectively only has three fully-functional centralised Council landfill sites, one of which is scheduled to be closed at the end of 2006. Durban has only two fully-functional centralised Municipality landfill sites with one currently functional and two planned sites on the outskirts of the region. These decentralisation phenomena further motivate the need to increase material recovery to save landfill airspace. The models show that this proposition is financially feasible.

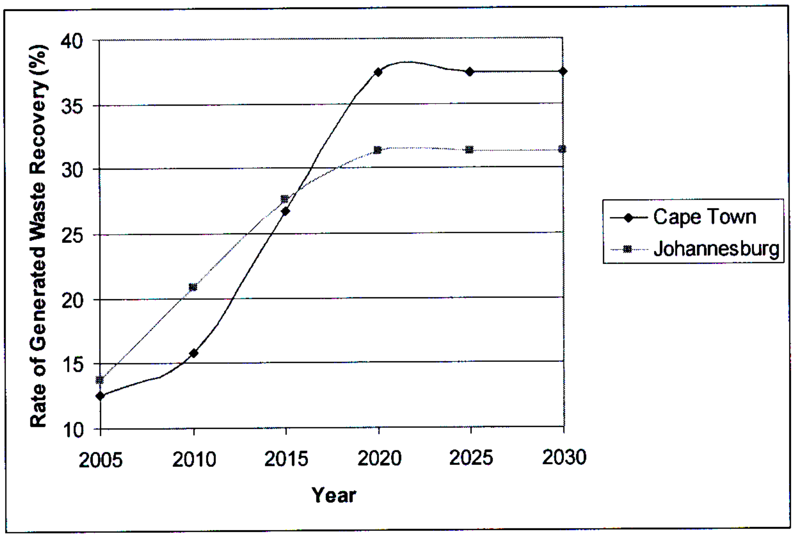

Figure 1. Modeled optimum waste recovery rates for Cape Town and Johannesburg.

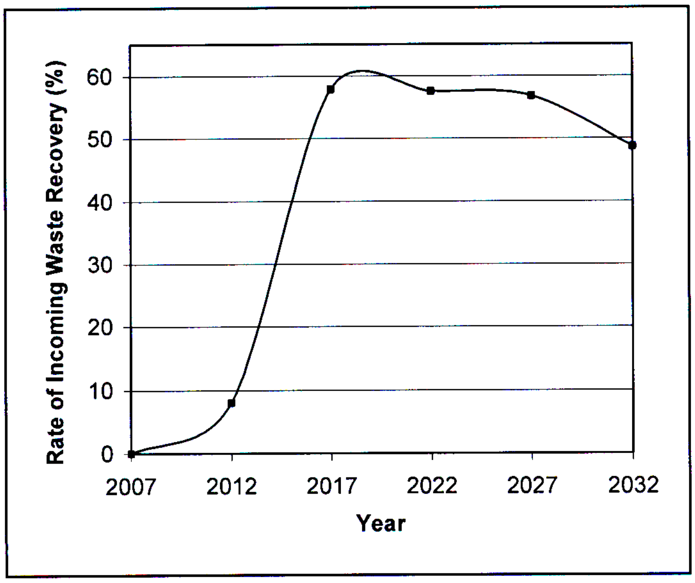

Figure 2.Modeled optimum waste recovery rate for Durban.

4. CONCLUSIONS

The communities of Mariannhill Park and Nazareth have been used as a case study for the introduction of a ZERO WASTE scheme into an already existing integrated waste management system. The Cost Benefit Analysis conducted shows that the project will be worthwhile economically. Environmental benefits in terms of landfill space savings will also be achieved by the introduction of a waste minimisation scheme incorporating both communities. A detailed analysis of implementation costs as per transportation and educational campaigns need to be conducted.

Significant changes to the waste streams are required to be substantially reduced for Johannesburg, Cape Town and Durban to comply with the Polokwane Declaration.. Decreasing the landfilled waste stream is not only required by legislation, but the developed models show that the recovery of waste also reduces the overall MWMS operational costs.

Different waste minimisation schemes were considered to be appropriate for each respective city, but the use of Material Recovery Facilities was found to be the most favourable option for all three cities.

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