Towards a sustainable incremental waste management system in Enkanini: A transdisciplinary case study

by

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Declaration

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Abstract

As the global population grows and more countries industrialise, waste streams will grow proportionately. Current waste management practices and product manufacturing processes dictate that a large proportion of waste ends up in a landfill or incinerator. The predominant manufacturing design is a linear, one-way model that extracts resources for manufacture, which eventually end up in a landfill or incinerator, rendered useless. This is an unsustainable use of resources, not only of the ones that were extracted to manufacture the product, but also of the land used to dump waste.

Along with this goes the increasingly significant issue of food waste and the issues of global hunger and food insecurity. It is estimated that globally one third of all food that is produced is wasted, equalling a total of 1.3 billion tonnes of food waste a year. Wastage of food causes a loss of potentially valuable food sources, or a potential resource for other processes, such as composting or energy generation.

The poor are normally the first affected by limited or dwindling resources, and as yet, there are no significant signs of poverty alleviation. Worldwide, there is a proliferation of informal settlements, or slums, and how to deal with these settlements has formed part of international political and societal discourse for a long time. In South Africa, policies dictate that informal settlements should undergo an incremental, in situ upgrading process, where possible. Although this marks a positive development from the previous housing policy, substantial uptake on the ground has as yet not occurred.

Consequently, this study attempted to combine the issues of waste management, in particular of food waste, and incremental upgrading of informal settlements through a transdisciplinary case study that focuses on upgrading the food waste management system in Enkanini, an informal settlement in Stellenbosch, South Africa. A waste characterisation study undertaken by Stellenbosch Municipality showed that food waste makes up a substantial part of the waste stream generated in Enkanini. As informal settlements often lack adequate waste collection services, the food waste poses a health risk by breeding pathogens and attracting pests.

Through a transdisciplinary approach, an alternative food waste treatment method was piloted in Enkanini in partnership with Stellenbosch Municipality and Probiokashi (Pty) Ltd. The method used bokashi substrate to treat food waste with microorganisms. This was then processed further into compost through the sheet mulching method and by black soldier fly

(*Hermetia illucens*) larvae. The outcomes were assessed according to the environmental, social and economic sustainability of this method of waste processing and indicated a positive impact in all three of these categories.

Opsomming

Soos die globale samelewing groei en al hoe meer lande industrialiseer, sal afvalproduksie ook proporsioneel toeneem. Moderne afvalbestuurpraktyke en vervaardigingsprosesse behels dat groot volumes afval in vullingsterreine of verbrandingsoonde beland. Vervaardiging behels hoofsaaklik ’n lineêre proses, waarin grondstowwe vir vervaardiging onttrek word en uiteindelik in sodanige vullingsterreine of verbrandingsoonde beland. Hierdie produkte is dan onbruikbaar. Hierdie praktyk is ’n onvolhoubare manier om hulpbronne te gebruik, nie net wat die grondstowwe vir vervaardiging betref nie, maar ook die grond wat gebruik word om die afval op te stort.

Verwant aan hierdie probleem, is die kwessie van toenemende voedselvermorsing en die probleme rondom wêreldwye hongersnood en voedselonsekerheid. Daar word benader dat een derde van alle voedsel wat ter wêreld vervaardig word, vermors word. Dit kom neer op 1.3 miljard ton voedsel per jaar. Voedselvermorsing veroorsaak ’n verlies aan waardevolle, potensiële voedselbronne of potensiële hulpbronne vir ander prosesse, soos bemesting en energievervaardiging.

Die armes is gewoonlik diegene wat die gouste deur beperkte of afnemende hulpbronne geraak word en, tot nog toe, is daar geen beduidende vordering in armoedeverligting nie. Wêreldwyd is daar ’n toename in informele nedersettings, of agterbuurte, en maniere om hierdie probleem aan te spreek, vorm lankal deel van die internasionale politiese en maatskaplike diskoers. In Suid-Afrika dui beleide daarop dat informele nedersettings, waar moontlik, ’n inkrementele, *in situ* opgraderingsproses moet ondergaan. Alhoewel hierdie plan ’n verbetering is op die vorige behuisingsbeleid, het wesenlike vordering nog nie plaasgevind nie.

Gevolglik het hierdie studie gepoog om die kwessies rakende afvalbestuur, spesifiek van voedselafval, en inkrementele opgradering van informele nedersettings in ’n transdissiplinêre gevallestudie te kombineer deur te fokus op die voedselafvalbestuurstelsel in Enkanini, ’n informele nedersetting in Stellenbosch, Suid-Afrika. ’n Studie, uitgevoer deur Stellenbosch Munisipaliteit, wat die inhoud van vullis ontleed het, het bevind dat voedselafval ’n beduidende deel vorm van die vullis wat in Enkanini geproduseer word. Aangesien informele nedersettings dikwels tekortskiet aan voldoende vullisverwyderingsdienste, hou voedselafval ’n bedreiging in omdat patogene daarin broei en dit peste lok.

Deur middel van ’n transdissiplinêre benadering is ’n proefprojek aangepak waartydens ’n alternatiewe metode om voedselafval te behandel, getoets is. Hierdie projek is in samewerking met Stellenbosch Munisipaliteit en Probiokashi (Pty) Ltd (Edms.) Bpk. in Enkanini uitgevoer. Hierdie metode het van bokashi-substraat gebruik gemaak om deur middel van mikroörganismes die voedselafval te behandel. Dit is daarna verder deur swartsoldaatvlieglarwes (*Hermetia illucens*) tot kompos verwerk. Die uitkomste van die studie is geassesseer ten opsigte van die sosiale, ekonomiese en omgewingsvolhoubaarheid van dié afvalverwerkingsmetode. ’n Positiewe impak is in al drie hierdie kategorieë opgemerk.

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List of Abbreviations

BBBEE – Broad Based Black Economic Empowerment

BNG – Breaking New Ground

BSF – Black Soldier Fly

BSFL – Black Soldier Fly Larvae

BSL – Bellville South Landfill

CC – Community Contractor

CEP – Community Engagement Programme

CORC – Community Organisation Resource Centre

DBSA – Development Bank South Africa

DEA – Department of Environmental Affairs

EM – Effective Microorganisms

EPWP – Extended Public Works Programme

ERC – Enkanini Research Centre

FAO – Food and Agriculture Organisation

GHG – Greenhouse Gas

ISN – Informal Settlement Network

ISUG – Informal Settlement Upgrading Group

IY – Imizamo Yetu

KIWMF – Kraaifontein Integrated Waste Management Facility

KTS – Klapmuts Transfer Station

MRF – Material Recovery Facility

MSW – Municipal Solid Waste

MT – Metric Tonnes

MTS – Municipal Transfer Station

NGO – Non-governmental Organisation

NPC – Non-profit Company

NRF – National Research Foundation

NUSP – National Upgrading Support Programme

RDP – Recovery and Development Programme

SAMWU – South African Municipal Workers Union

SDI – Shack/Slum Dwellers International

SI – Sustainability Institute

SITT – Stellenbosch Infrastructure Task Team

SU – Stellenbosch University

TD – Transdisciplinarity

TR – Transdisciplinary Research

UISP – Upgrading of Informal Settlements Programme

UN – United Nations

Chapter 1 : Introduction

1.1 Background to this study

This chapter introduces a transdisciplinary Master's research study on the waste management system of Enkanini, an informal settlement in Stellenbosch, South Africa. The research was a complex and unusual process of which an overview is given in this chapter. This section explains the origin of the research group and overall research theme that this study forms a part of. Section 1.2 gives a background introduction to Enkanini, the primary setting in which the research was conducted. Section 1.4 briefly contextualises the study in transdisciplinary literature, and the broader setting of waste management in Stellenbosch and South Africa, before delving into a more detailed explanation of the research process and why it was of an unusual nature in Section 1.5. Included in this explanation is a clarification and description of transdisciplinarity (TD) and transdisciplinary research (TR), as TD was the methodological approach used in this study and TR is the overall method used by the research group that this study was part of. The research group will be explained further in the next paragraphs.

The Transdisciplinary, Sustainability, Analysis, Modelling & Assessment Hub, more commonly referred to as the TsamaHUB, is an academic structure at Stellenbosch University (SU) situated within the Faculty of Economic and Management Sciences. It was established to facilitate and co-ordinate the Doctoral Programme for applied solution-based sustainability research and to promote transdisciplinary studies in and around the Stellenbosch area. Transdisciplinary studies transcend disciplinary and institutional boundaries in an attempt to understand complex socio-ecological systems and find new, innovative approaches to the problems found embedded within these systems (TsamaHUB, [n.d.]). The TsamaHUB represents a well-connected network of academics of different SU faculties, who all share an interest in complexity theory, sustainability research and transdisciplinary ways of working. Part of this network of faculties is the Sustainability Institute (SI), through which this study was completed.

In 2011 the National Research Foundation (NRF) awarded the TsamaHUB funding for a three-year period. The NRF had put out a call for proposals for research on community engagement in their Community Engagement Programme (CEP) (National Research Foundation, 2012). In broad terms, the CEP aims to support researchers to facilitate the dissemination and transfer of knowledge. The TsamaHUB recognised an opportunity to establish a research group under the umbrella of the CEP, with a specific focus on

incremental informal settlement upgrading. The research group is known as the Informal Settlement Upgrading Group (ISUG) and constitutes researchers with various disciplinary backgrounds, from various departments of SU, all pursuing their Master's and doctoral degrees.

1.1.1 Background on informal settlement upgrading

Internationally, the topic of how to deal with the problems informal settlements cause has been debated for three decades before a broad consensus was reached, amongst a large variety of actors, that in situ upgrading of these settlements is the most appropriate approach (Abbott, 2001). In 2004, in line with this international consensus, the South African government shifted its approach to human settlements by implementing the "Breaking New Ground": A Comprehensive Plan for the Development of Sustainable Human Settlements (BNG) policy (Del Mistro & Henscher, 2009). This can be viewed as an attempt to amend many of the shortcomings of the previous housing policy (Huchzermeyer, 2006), widely known as the Reconstruction and Development Plan (RDP). One of the key shifts in the BNG policy was the mandate for local governments to create sustainable human settlements (Madlala, 2007) under which the Upgrading of Informal Settlements Programme (UISP) falls.

The UISP promulgates in situ incremental upgrading of informal settlements, where feasible (Republic of South Africa, 2009), as opposed to the RDP housing strategy that advocated eradicating informal settlements and moving residents to green-field developments in distant locations with weak socio-economic infrastructure (Republic of South Africa, 2004). New funding mechanisms and support programmes were established, such as the National Upgrading Support Programme (NUSP), to help local governments implement this policy shift on the ground. However, despite these measures, the widespread adoption of the policy on a national scale has still not materialised (Huchzermeyer, 2009).

One of the reasons why take-up has been slow is the lack of an agreement on an international level as to the most effective way of achieving in situ informal settlement upgrading (Abbott, 2001). Hence, a wide range of diverse approaches has been adopted in this undertaking, each with varying degrees of success. None of them has stood out as the approach to consolidate the varying opinions amongst actors. The approaches, thus far, can be categorised into those that are associated with more traditional, top-down development infrastructure and those that emphasise process and community control (Abbott, 2001). Due to the predominant failure of the traditional planning and engineering approach, the approach that emphasises community management and control has taken precedence and has been championed by the non-

governmental organisation (NGO) sector. This approach has recognised that the issue with informal settlements and those inhabiting them is not just one of poverty but also a much deeper issue of vulnerability caused by social exclusion. Hence, importance has been placed on social integration through settlement transformation, which is much more encompassing than the sole aspect of physical upgrading (Abbott, 2001). Although this recognition is important, this approach has also not proven itself to be effective enough to reverse the growth of informal settlements.

Therefore, physical upgrading should take place using social inclusion tactics. This should be done through a methods-based approach that can be replicated on a large enough scale to cease the proliferation of informal settlements worldwide. This sums up the overall objective of the ISUG. The approach of this research group in tackling this life-world[1] problem is transdisciplinary in nature and promotes the co-production of knowledge that is critical for enabling sustainable transitions at the local level, in this case Enkanini (TsamaHUB, 2011). By focusing on physical elements of the upgrading process, such as service delivery, the ISUG hopes to achieve research outcomes that contribute to finding practical solutions to this life-world problem that will simultaneously achieve social integration and settlement transformation. The first generation of ISUG researchers focused on topics such as energy poverty, water and sanitation provision, and ecological dwelling design (also known as eco design). This study forms part of the second generation of ISUG research, and was included because of its focus on solid waste management. Solid waste management forms part of the services that the ISUG is focusing on, along with electricity supply, water and sanitation infrastructure, and storm water drainage among others, and hence there was a need for research on solid waste management in the group. It is envisaged that successive researchers will build upon the research done by previous ISUG members, forming a long-term 'centre-of-expertise' on developmental responses to informality.

1.1.2 A focus on waste management within informal settlement upgrading

Waste management is a topic of concern around the world, regardless which stage of development a country is in. The concern stems mainly from the recognition that the global culture is predominantly either already entrenched in consumerism, or is unwaveringly

[1] *Life-world* refers to the human world prior to scientific involvement (Hirsch Hadorn *et al.*, 2008). In this thesis, the term is used to refer to the everyday world.

heading in that direction, and consequently creating unprecedented amounts of solid waste (Strasser, 1999). The predominant ways of disposing of waste thus far have been to dump it all in a landfill, or worse, into the sea (McDonough & Braungart, 2002). Had products not been composed of non-degradable and often-toxic materials, this may not pose such a big threat to the environment. However, a majority of products take years and sometimes centuries to biodegrade, while others, such as certain plastics, do not biodegrade at all due to their chemical and physical properties (Tokiwa, Calabia, Ugwu & Aiba, 2009). This means that waste is filling up landfills dangerously fast, outlasting many generations. And if it does biodegrade, it poses an additional threat to the environment because of its often toxic chemical makeup.

Added to the dilemma of toxic and non-degradable products, is an overall trend in the world that has manufacturers designing products according to what McDonough and Braungart (2002) term a 'cradle-to-grave model'. This means that products are designed for the dump when they are conceptualised, instead of designed as a 'cradle-to-cradle' model (McDonough & Braungart, 2002), where products have a certain imperishability and can be reused and upcycled endlessly, never rendering them useless. The 'cradle-to-grave' model causes products to lose their usefulness after a certain time, and thus they are destined for landfills or incinerators.

The waste that is thrown away does not only consist of products made up of chemicals, such as soft or hard plastics and polystyrene, but also of food waste. Some studies have suggested that on a global scale, a third of all food produced for human consumption is wasted (Gustavsson, Cederberg, Sonesson, van Otterdijk & Meybeck, 2011 cited in Oelofse & Nahman, 2013). This equals an estimated 1.3 billion tonnes of food waste per annum globally (Food and Agriculture Organisation, 2013). These food losses occur at all stages of the supply chain, whether during agricultural production, during transportation, during storage or during final household consumption (Gustavsson *et al*., 2011 cited in Oelofse & Nahman, 2013). The causes of food wastage are different to the reasons why overall solid waste is increasing, as mentioned above. Food wastage causes vary for countries with different income levels. In medium to high-income countries, food waste has been linked mostly to consumer behaviour and an uncoordinated organisation between supply chain actors, while food wastage in low-income countries has been linked to technical limitations in things such as harvesting techniques, infrastructure, and cooling and storage facilities (Gustavsson *et al*., 2011 cited in Oelofse & Nahman, 2013).

Although food waste is biodegradable, therefore degrading quicker than other consumer waste, it comes with its own set of problems that pose significant obstacles to local government, engineers and sustainability professionals. Food waste is not made up of chemicals whose toxins are a threat to humans and the environment, but food waste does putrefy and hence produces pathogens, which pose a risk to human health. Further, leachate of food waste can have a negative impact on groundwater and rivers (Oelofse & Nahman, 2013). Food waste also produces greenhouse gas (GHG) as well as odours and attracts pests (Oelofse & Nahman, 2013). Lastly, food wastage also exacerbates food insecurity (Oelofse & Nahman, 2013), which makes food more expensive and hard to come by, affecting the poorer communities especially.

The problem of waste is inextricably linked to our ability to create a sustainable future, because reducing waste is dependent on external and internal changes in our lifestyles and behaviour. External solutions are, for example, such things as finding more environment-friendly materials and redesigning our products for 'upcyclability' instead of for the dump (McDonough & Braungart, 2002). However, reducing waste is also dependant on internal behavioural shifts. This entails becoming more aware of what we throw away and making an effort to change wasteful behaviours that have been fostered by consumerism and the convenience factor[2] (Strasser, 1999). These two changes of both external and internal nature are the bases on which we can develop in more environmentally, socially and economically sustainable ways. Chapter 2 will provide more detail of waste in relation to sustainable development and poverty.

1.2 Background of Enkanini informal settlement

Enkanini located in Stellenbosch (not to be confused with Enkanini in Khayelitsha), borders on the semiformal township of Kayamandi and is estimated to house almost 4500 people (see Figure 1.1). It was established in 2005 (Community Organisation Resource Centre, 2012) after some backyard dwellers from Kayamandi successfully negotiated with the municipality to informally reside on an empty piece of land adjacent to Kayamandi (Keller, 2011a). However, local authorities started resisting the expansion of informal settlers as new arrivals started setting up shacks in the same area (Ntsokhota & Tyawa, 2013). The expansion took place without consent from local government and thus the entire settlement is now illegally

[2] The convenience factor refers to convenience of disposability of items as a result of the demise of thrift (Strasser, 1999).

situated on municipal-owned land. Hence the name ‘Enkanini’ was born, which means ‘to force something’ or ‘taken by force’ in Xhosa.

Figure 1.1 Satellite image depicting Enkanini (encircled in blue), the location of Kayamandi (indicated by a green arrow) and the location of Plankenbrug (indicated by a yellow arrow).

Source: Google Earth. 2013. [Online] Available: http://www.google.com/earth/. GPS co-ordinates: 33°55'28.18"S, 18°50'41.57"E. [20/10/2013]

Road access to the settlement is extremely limited due to the difficult geographic placement and the haphazard positioning of shacks. The two dirt roads that are the main arteries leading into the community and the narrower paths connecting them are all in poor condition, especially after heavy rains. The municipality has only provided the settlement with the most essential basic services. This is partly due to the illegal land tenure of Enkanini. Further, neighbouring Kayamandi is prioritised in terms of service provision because: (1) it has existed far longer than Enkanini, (2) it is a semiformal township, which puts it higher on the priorities list and (3) it already has a service backlog that needs to be addressed (SITT, 2012). Thus, the majority of people living in Enkanini do not have electricity, except those who tap it illegally from Kayamandi or Plankenbrug, the neighbouring industrial area (see Figure 1.1). For other basic services such as water and sanitation, the residents make use of the 32

communal taps and 80 communal flushing toilets in the settlement (Community Organisation Resource Centre, 2012).

In addition to the minimal basic service provision of water and sanitation for Enkanini, the municipality has placed seven concrete waste bays, also known as municipal transfer stations (MTSs), along the roads that are most accessible by municipal waste collection vehicles. Along with providing the minimum level of free basic services to low-income areas, the municipality is duty-bound to perform household waste removal on a weekly basis, as put forward by the Municipal Systems Act 32 of 2000 (Republic of South Africa, 2000), which states that municipalities must

1. "Give priority to the basic needs of the local community";
2. "Promote the development of the local community"; and
3. "Ensure that all members of the local community have access to at least the minimum level of basic municipal services" (2000:34)

Furthermore, according to this law, municipalities must also ensure that services are economically and environmentally sustainable as well as equitable and accessible. Services must be reviewed regularly with a view of upgrading, extension and improvement (Republic of South Africa, 2000). This means that municipalities are duty-bound to ensure the above-mentioned measurements are performed regularly.

Figure 1.2 Satellite image depicting the seven MTSs, or concrete waste bays , in Enkanini.

Source: Google Earth. 2013. [Online] Available: http://www.google.com/earth/. GPS co-ordinates: 33°55'28.36"S, 18°50'52.59"E; 33°55'26.21"S, 18°50'52.51"E; 33°55'20.25"S, 18°50'35.04"E; 33°55'21.47"S, 18°50'32.77"E; 33°55'25.78"S, 18°50'27.99"E; 33°55'28.87"S, 18°50'41.19"E; 33°55'34.18"S, 18°50'46.93"E. [20/10/2013]

1.3 A summary of the research study

The context of this study is an informal settlement, whose residents feel discontent and frustrated with the lack of service delivery and the substandard living conditions resulting from this. This has led to a tenuous relationship between Enkanini and the municipality. The municipality regards Enkanini as an extremely volatile settlement and there has been no clear plan of action of how to best deal with the settlement. A history of aggression and violence by residents, exhibited through protests and vandalism, has in many instances rendered municipal officials immobile as well as unwilling to search for alternative ways of engaging with residents and working towards upgrading the settlement.

This research study consisted of engaging with multiple, diverse actors within the context of the waste management field and informal settlement upgrading in a transdisciplinary research process. The interaction and engagement led to an opportunity to implement an intervention in Enkanini that focused on an alternative food waste management method, with the support of Stellenbosch Municipality and in partnership with a private company by the name of Probiokashi (Pty) Ltd. Saliem Haider, the manager of the solid waste department at the municipality, played an integral part in making the intervention possible, along with Rupert

van der Merwe, the proprietor of Probiokashi (Pty) Ltd. The NRF primarily funded the study, and financial contributions were received from the municipality towards the pilot project.

The intervention was set up as a pilot project that involved 100 households, which were required to separate their food waste into separate buckets and treat this food waste with a product called bokashi. Bokashi is a substrate that is inoculated with lactic acid bacteria, also called 'beneficial microorganisms'. These bacteria induce a fermentation process of the food waste, which essentially increases the choice of final processing methods as the lactic acid bacteria eliminate pathogens and neutralise the pH levels (this is discussed in detail in Section 3.4.2). The households were required to drop their food waste at a specific location within the settlement, where it was weighed and recorded. Participation was monitored and feedback on the method was obtained from participants, with the intention of incorporating the feedback into subsequent phases if the method was determined as sustainable.

1.4 A personal contextualisation of the research study

After completing the BPhil in Sustainable Development, the prerequisite for the MPhil, at the end of 2011, I started familiarising myself with the context of the ISUG. At that point I had already decided that my research should focus on household waste, and it was suggested to me by Eve Annecke, the founding director of the Sustainability Institute, that I combine my research with the research that the ISUG was already undertaking. After a few meetings with the researchers of the ISUG and visiting Enkanini, the overall aim of my research took shape, namely to contribute to increasing the sustainability of the current waste management system in Enkanini.

This overall aim was shaped mainly through observations made while walking through the settlement, as it was obvious that the current system was not functioning properly. Waste was accumulating in non-designated areas and concrete bays were overflowing (see Figure 1.3 and Figure 1.4). The overall research aim was an appropriate fit within the ISUG, whose aim is to determine how to incrementally upgrade services in informal settlements in a sustainable manner. Therefore, the research on waste management contributes suitably to the research on ecological dwelling design, electricity, water provision and sanitation.

Figure 1.3 A concrete bay in Enkanini that has not been collected for several weeks (photograph taken by author, 2012).

Figure 1.4 Waste accumulating in a non-designated area (photograph taken by author, 2012).

The overall research framework of the ISUG is guided by transdisciplinary methodology (TD). TD, which in the literal sense means to transcend disciplinary boundaries (Mittelstraß, 1992), was an apt approach for this research as it allowed for me to research a topic that I had little disciplinary background in. I had just completed the BPhil in Sustainable Development, which gave me a broad grounding in the sustainability field. However, with an undergraduate degree in Marketing, I had little experience in - and academic knowledge of engineering and

the social sciences, which are the other relevant disciplinary categories in waste management, particularly in the setting of informal settlement upgrading.

A lack of expert knowledge in these fields surely contributed to a certain sense of insecurity as to whether the overall aim of my research would be accomplished. However, TD research is about consulting various experts and actors in the life-world and the academic world in order to combine their knowledge sets, and therefore it was not required that I, the researcher, be the holder of expert knowledge, but rather that I execute the integration thereof. Hence, the principles and intent of TD were taken as guidance in this study, such as the principles of open encounters, reducing complexity and integrating knowledge (Pohl & Hirsch Hadorn, 2007). Through these, knowledge sets were combined in such a way that the research outcomes contributed to shifting Enkanini's waste management system into a more sustainable direction. This was gauged by the willingness of a majority of stakeholders to continue with the alternative system that was piloted during the research. (This is elaborated on in Chapters 3 and 4.) Furthermore, a lack of expert knowledge was particularly advantageous in putting me on an equal footing with Enkanini residents, as I did not presume to have the answers to their problems. This stimulated a more intensive two-way knowledge transfer between the residents and me. The notion of two-way knowledge transfer will be expanded upon in Section 1.5.1.

1.5 An unusual research process

At this point it is necessary to mention a few factors that had an impact on the research process to such an extent that it was executed very differently from a usual Master's research process. The most impactful divergence from the norm was that there was no requirement to have a fixed problem statement, let alone research question, at the commencement of the research. It is typical of a TD researcher to enter a certain life-world context that offers an opportunity to investigate a life-world problem without a pre-established research question or problem statement. This is something that is identified and structured during the first phase of the research process in TR (Pohl & Hirsch Hadorn, 2007). That is why the first phase in such a research process is called "problem identification and structuring" (Pohl & Hirsch Hadorn, 2007:44) or the "explorative phase" (Hirsch Hadorn, Hoffmann-Riem, Biber-Klemm, Grossenbacher-Mansuy, Joye, Pohl, Wiesman & Zemp, 2008:48). The intention is that TD research, during this phase, will consider existing disciplinary and life-world perspectives of the problem that will help to structure it in such a way that it "enables exploration of the

complexity [of it,] relevant to practice-oriented solutions" (Pohl & Hirsch Hadorn, 2007:44). The details of the TD research phases will be discussed in Section 1.8.1.

Therefore, the requirement for the beginning stages of this research study was primarily "to engage with the actors that formed part of the context of Enkanini" (Swilling, 2013; TsamaHUB, 2011). The lack of a pre-established research question had an effect on the way the study was executed, for example allowing freedom and flexibility in responding to life-world situations and changing circumstances.

As mentioned above, the ISUG is funded by the NRF under the section of community engagement programmes and it is clear from the funding proposal that 'engagement' is a primary objective of the ISUG (TsamaHUB, 2011:6). The proposal states that the applicants believe that engagement leads to opportunities for the co-production of knowledge (TsamaHUB, 2011:6). The overall objectives for the project, as listed in the funding proposal, revolved around aspects such as building trust with relevant stakeholders, exploring transdisciplinary production of knowledge and developing and adapting the researchers' current understanding of TD as a methodology for community engagement to suit the particular challenges and conditions of the given context (TsamaHUB, 2011). These focus points signify the intent of the TsamaHUB's project, which is to enter a community such as Enkanini without any pre-established solutions derived from theoretical analyses, but rather to let solutions or ideas emerge through life-world experiences by means of practical research and engagement processes that foster co-production and co-development, in true TD form (Regeer & Bunders, 2008). The same intent was adopted for this research.

Furthermore, the overall intent of TD was adopted for the study, namely to conduct scientifically sound research through community engagement by combining real-life experiences and skills with scientific knowledge to produce knowledge with society and thus to produce real-world solutions. This provided a foothold to enter the research process and guided me through the engagement process throughout the research process (this will be discussed in detail in the rest of this chapter). I did not follow a strict methodology, or 'recipe', since I felt that this would restrict the natural unfolding of the research process and stifle its exploratory nature. This, I felt, would prompt the development of knowledge and practices that promote what is perceived to be the 'common good' (Hirsch Hadorn *et al*., 2008). Further, I wanted to develop sincere relationships of trust and understanding that emerged naturally and organically. Therefore, multiple methods were used and methods were selected as the need for them arose (see Chapter 3 for more detail on methods).

For the reader to fully understand the research process it is necessary to capture the essence of TD and hence the overall approach that was adopted during this study. In order to do this, the literature of several prominent TD scholars will be covered, starting with a broad contextualisation, namely a theoretical interpretation of TD. This will then be narrowed down to explain how TD was applied in this research and the TD principles that guided the study will be listed. Lastly, the research process will be embedded into a TD framework as a retrospective action to allow for a smoother and more structured format to present the study.

1.6. A theoretical interpretation of transdisciplinarity

In this section a brief historical account of TD is given, followed by an explanation/definition of what TD is. Different kinds of knowledge sets that TR deals with are explained and the notion of the power of knowledge is expanded upon. Lastly, an overview of the four main principles of TD that were influential in this study is given.

1.6.1 A historical account of transdisciplinarity and an attempt at a definition

The physicist, Erich Jantsch, was the first to use the term 'transdisciplinarity', in 1970, and even though TD has since been endlessly discussed and debated and has gained in popularity in the academic world, a commonly accepted understanding thereof has still not emerged (Jahn, 2008). When Jantch first referred to TD, he only referred to the targeted coordination of a group of disciplines and interdisciplines. In 1998, the philosopher Jürgen Mittelstraß defined TD as "a form of research practice that has freed itself from disciplinary boundaries, defining and solving its problems independently of any discipline" (Jahn, 2008:1). The 1990s marked an important development in describing TD as a new mode of scientific knowledge production, termed mode 2 (see Table 1.1). Mode 2 differs from mode 1 and mode 0, the traditional academic modes[3], in that it includes the interest of economic, political and societal actors in the research process (Jahn, 2008). This development was highly controversial, but led to a heterogeneous form of research practice being established, especially in environmental, sustainability, health and developmental research domains – contexts that are

[3] Mode 0 and mode 1 are more traditional forms of research, as they do not entail the coproduction of knowledge as in mode 2. Mode 0 makes use of monodisciplinary knowledge and separates science and society completely, whereas mode 1 cooperates between science and society in interdisciplinary ways, but only mode 2 coproduces knowledge between science and society and utilises experiential knowledge.

well-suited to TD. As there is no commonly accepted understanding of TD, some interpretations of TD relevant to the context of this study are listed in the next few paragraphs.

Max-Neef (2005), a Chilean economist and pioneer in TD, describes TD as a systemic and holistic way of tackling real-world problems. He postulates that, in its essence, TD is a different manner of seeing the world and a way of transcending various levels of reality. This is because it allows for gaining a broader perspective of the life-world problems that are embedded in a system composed of various elements, spanning many disciplines and forms of knowledge. Hence, Max-Neef maintains that TD can be understood as complementary to the concept of 'disciplines'. TD is not seen as a separate super-discipline. According to Max-Neef (2005), TD is to disciplinarity what yin is to yang – forming a *complementary* relationship whereby TD can only exist in symbiosis with disciplinarity and whereby transitioning from one to the other affords glimpses into different levels or perceptions of reality, thereby enriching the understanding of these different realities (Max-Neef, 2005). Max-Neef thus sees TD as the coordination between different hierarchical levels of disciplinarity.

Scholz ([n.d.]), the speaker of the International Transdisciplinarity Network on Case Study Teaching, explicitly adds to Max-Neef's description that TD is a paradigm characterised by societal knowledge, which Max-Neef (2005) only alludes to as the importance of intuitive knowledge in TD. Scholz ([n.d.]:13) describes TD simply as "mak[ing] the change from research *for* society to research *with* society" (own emphasis). This means that the intent of TR is not only to produce, integrate and manage knowledge between multiple disciplines (Scholz, [n.d.]) but also for science to co-operate with society and, in this way, co-produce knowledge. It is in this, the integration of science with society, that TD differs from multidisciplinary and interdisciplinary research. Table 1.1 gives an overview of the different roles that scientific knowledge development has in the different research modes.

Table 1.1 The role of scientific knowledge development in the different research modes.

	Relationship between science and practice	Presumed role of scientific knowledge (development)	Type of knowledge
Mode-0	SEPARATE Science and society are separate from one another.	AUTONOMOUS More scientific knowledge leads to more progress.	Monodisciplinary knowledge. Emphasis on sciences.
Mode-1	CO-OPERATION Co-operation between science and society. No change in working methods of either.	INSTRUMENTAL Development of policy-relevant knowledge leads to the resolution of societal problems and stimulates the economy. Harmonization activities.	Mono-, multi- and interdisciplinary knowledge. Natural and social sciences.
Mode-2	CO-PRODUCTION Practice and science both actively seek the best way to structure and manage complex change processes.	TRANSDISCIPLINARY Scientific knowledge (mono-, multi-, and inter-disciplinary) is part of the joint solution process AND the process is part of scientific knowledge development.	Mono-, multi- and interdisciplinary knowledge. Also experiential knowledge.

Source: Regeer & Bunders (2008:12)

As can be seen in the table above, TD acknowledges that knowledge is not only produced at universities and in science but also in societal fields. It therefore includes experiential knowledge, in other words knowledge of everyday life, lay knowledge and tacit knowledge (Scholz, [n.d.]; Hirsch Hadorn *et al*., 2008; Regeer & Bunders, 2008; Darby, 2006). Therefore, there are essentially two different types of knowledge according to Scholz ([n.d.]): the intuitive, experiential knowledge of case agents and the analytic, abstract knowledge of scientists. Through integrating these different knowledge sets and encouraging mutual learning, TR has the capacity to deal with the complexity and diversity of the problems of the everyday world (Pohl & Hirsch-Hadorn, 2007). Hence, a TD approach allows the researcher to integrate different knowledge sets through entering different realities without needing expert knowledge of those different realities. This can be done through various modes of integration, which are expanded upon in Chapter 3, but essentially the researcher takes on a facilitator role between various actors and between scientific and experiential knowledge.

1.6.2 Power of knowledge

The notion of 'entering different realities' can also refer to TD's capacity to level power relations between different actors, but more specifically between different knowledge sets, because both scientific knowledge and experiential knowledge are viewed as equally important within this paradigm (Regeer & Bunders, 2008). Throughout this study this notion will be referred to as the 'power of knowledge'.

In the 1970s the idea that "scientists possessed knowledge that is more 'true' than that of other parties" has come into question, and the belief that science is a 'finder of truth' has become a myth (Regeer & Bunders, 2008:48). The supremacy placed on reductionism as well as binary and linear logic in the world of science has led to the exclusion of other types of knowledge that originate from other ways of knowing (Max-Neef, 2005). For example, even though intuition has always played a big role for innovators in all fields, in the sciences as well as the arts, confessing the contribution of intuition to one's work is seen as unacceptable and not worthy of a true scientist (Max-Neef, 2005). Einstein once declared that "the intuitive mind is a sacred gift, and the rational mind is a faithful servant". He said, "We have created a society in which we honour the servant and have forgotten the gift." (Einstein cited in Max-Neef, 2005). Therefore, the role that intuition played in decision-making during the research process will be openly acknowledged when this was the case.

Furthermore, the belief that scientific knowledge is truer than other kinds of knowledge has led to the assumption that citizens first have to acquire scientific knowledge before they are able to contribute valuable knowledge to discussions. This has led to the assumption that a one-way transfer of knowledge has to take place, from specialists to lay citizens (Regeer & Bunders, 2008). The idea that specialist knowledge needs to be transferred to laypersons and that they, in turn, do not have any knowledge to transfer back to specialists is referred to as the deficit model (Regeer & Bunders, 2008). This model proposes that lay citizens have a deficit of knowledge, which has to be made "good" before they can participate in discussions. Therefore, because I am a layperson in some of the fields this study covered, my research process included on a two-way transfer of knowledge between laypersons, specialists and academics.

The scientific realm of research is still predominantly ruled by mode 0 or mode 1 of knowledge production, but TD has brought into existence "a logic capable of harmonising reason with intuition and feeling" (Max-Neef, 2005:10) by including other types of knowledge production in a scientific manner that still leads to robust research results. TD

creates room for the intuitive, experiential knowledge that Scholz ([n.d.]) and Regeer and Bunders (2008) speak of, as "there is no hierarchical relation between scientific knowledge and societal knowledge, or experiential expertise (Regeer & Bunders, 2008:57).

1.6.3 The four principles of TD

There are four main principles of TD research according to Pohl and Hirsch Hadorn (2007). They are: (1) the principle of reducing complexity, (2) the principle of contextualisation, (3) the principle of open encounters and (4) the principle of recursiveness. These principles were followed closely during the research process.

1.6.3.1 The principle of reducing complexity

The first principle of TR is reducing complexity in order to establish a researchable question (Pohl & Hirsch Hadorn, 2007). TR deals with societally relevant problem fields, which are often diverse and complex in themselves, and therefore it is necessary for the researcher to reduce complexity, but in a manner that still allows one to grasp the complexity of the problem when establishing the research question. The orthodox research method of extreme reductionism is not what TD scholars Pohl and Hirsch Hadorn (2007) refer to. Rather, they argue that complexity of the problem can be reduced by identifying those involved and by specifying the need for knowledge in the life-world, which will be translatable to real solutions on the ground (Pohl & Hirsch Hadorn, 2007). This can be achieved by discerning what research questions need to be addressed and what the status quo of the current problem is according to the different stakeholders, or case agents, and thereby taking into account their different perspectives.

1.6.3.2 The principle of contextualisation

The second principle of TR is contextualising the problem within the life-world but also within the scientific context (Pohl & Hirsch Hadorn, 2007). This is important because TR aims to develop knowledge that will contribute to solving life-world problems. Thus, the problem must be contextualised within existing technologies, societal practices, regulations, power relations and the potential for change in order to make the results accessible to those concerned. It also needs to be contextualised within the scientific world by linking it to the relevant disciplines, by systematising it in order to achieve scientific robustness and by publishing experiences garnered in the project.

1.6.3.3 The principle of open encounters

The third principle of TR is open encounters (Pohl & Hirsch Hadorn, 2007). As Pohl and Hirsch Hadorn (2007) posit, this principle of open encounters is the most important

fundamental aspect for successful collaboration between actors and stakeholders of various disciplines. The importance of open encounters lies in accepting other views or perspectives as relevant as one's own in order to integrate various perspectives to arrive at a shared understanding of the problem. TD is not simply about integrating disciplines, but about a "brave, open-minded and all-inclusive handling of the many different perspectives that are always inherent in a real-world research problem" (Andrén, 2010:3). Integration of perspectives is aligned with the overall intent of TD of integrating knowledge, as perspectives are grounded in knowledge. Only through an open encounter can constructive discussions about the various perspectives, and the potentials thereof, take place. Collaboration between stakeholders and integration of knowledge can take various forms, which will be discussed in Section 1.7.

1.6.3.4 The principle of recursiveness

The fourth principle of TR is recursiveness (Pohl & Hirsch Hadorn, 2007). The fact that TR aims to (1) encompass complexity and diversity of a certain problem field, (2) develop knowledge that is both specific to a certain case but also transferable and scalable and (3) develop practice-oriented solutions for the common good is no small task and seems to only be possible to a limited degree. One way of increasing chances of accomplishing all aims is to shape the research process recursively. This means that the limitation or uncertainty of a preliminary result becomes a learning experience, rather than an obstacle. Each time a real-world solution is implemented it is seen as an experiment in order to observe and learn from outcomes for the next implementation.

1.7 Transdisciplinary methodology approach

This section explains why a TD approach was chosen and how it was applied in the research study. TD methodology was apt for this study for the following reasons: First, the overall approach of the ISUG is transdisciplinary in nature as it lends itself well to researching complex societal problems. Second, as the research interest was embedded in social dynamics and encompassed waste management systems, and I am qualified neither as a social scientist nor as an engineer, the TD approach allowed a transcendence of these disciplinary boundaries and enabled engagement in a mutual learning process, as discussed. Third, one of the motivating factors of joining the ISUG and researching incremental upgrading of waste management systems in informal settlements was to contribute to a practical and workable solution in the life-world. As Wickson, Carew & Russel (2006) state, one of the objectives of TR is to contribute to the solution of real-world problems through

practical outcomes that are applicable in their context and hence will bring about some degree of change in the real world. This concept was extremely important in this study as great emphasis was placed on practical, usable outcomes in completing this Master's degree.

As mentioned above, TD aims to do research *with* the society instead of research *for* the society (Scholz, [n.d.]). This statement helped me to grasp the importance of understanding the context of the community that the research would be conducted in and the importance of forming positive relationships with the residents of Enkanini as well as other stakeholders. Therefore, one of the primary objectives in the initial stages was to establish relationships with Enkanini residents and other actors that were built on mutual trust and respect. I believed that a strong relationship would be the precursor to unlocking valuable knowledge contributions from actors. Knowledge contribution to the process of co-production (see Chapter 2) is important because an alternative waste management system would be likely to fail if 'solutions' are designed without the participation and contribution of all stakeholders (Mitlin, 2006; Regeer & Bunders, 2008). Mitlin (2006:45) states "through co-production, social movements seek to engage the state on terms of the poor, not on those of the state".

Establishing these kinds of relationships is a process that takes time. This, coupled with the TD principle of joint problem identification and structuring, led to an approximately six-month process (December 2011 – June 2012) of developing a workable research question.

In retrospect, the absence of a research framework and research question worked in favour of the process in multiple ways. It allowed for a very organic and flexible evolution of the research process, of identifying the research question and further research objectives together with actors in the life-world, such as Enkanini residents and municipal officials. The lack of expert knowledge of the research topic also levelled the power relations between the Enkanini co-researchers and me as I did not, and could not, presume to have more knowledge or 'truer' knowledge than an outsider or 'scientist'. As already alluded to in Section 1.6.2, scientific or expert knowledge is still perceived to be more valuable than other forms of knowledge and this often leads to power imbalances between stakeholders and affects two-way knowledge transfer between them (Funtowicz & Ravetz, 2008). Knowledge is specifically linked to power because scientific knowledge has, in the past, been designed for "the traditional societal goal of the attainment of power" (Funtowicz & Ravetz, 2008:367). Not possessing scientific or expert knowledge in the chosen area of research enabled an approach that was characterised by an open attitude, as I did not find myself "in a superior and privileged knowledge position" (Andrén, 2010:6). Therefore, the co-researchers'

experiential knowledge of the life-world was just as valuable as the abstract, analytic knowledge scientists or specialists could provide, and both were needed to achieve the research objectives.

The initial uncertainty of achieving the overall research aim, namely contributing to a more sustainable waste management system in Enkanini, led to a practice of open encounters (one of the TD principles, as mentioned before) in a natural, but also necessary, attempt to find traction in the research subject. Thus, many connections were established within the first few months and a network of actors relevant to the overall aim of the research study was built up. Engaging in these open encounters with specialists and experts in the field of waste management led to several communication processes through which advantageous opportunities emerged, such as the opportunity to visit and gain detailed insights into various operations in the waste sector.

1.7.1 Influential TD characteristics

The four principles of TD (listed in Section 1.6.3) form the pillars of TD research (see Figure 1.5). This section provides a further iteration of TR characteristics, to provide the reader with a better understanding of these characteristics, as they were very prominent and influential in the research approach.

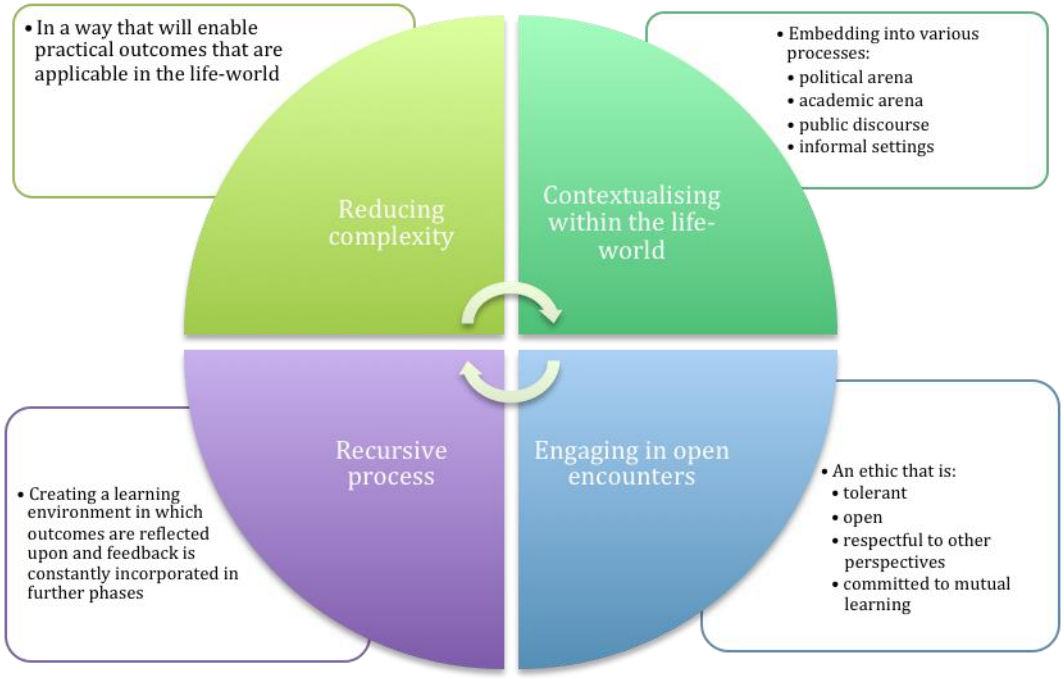


Figure 1.5 The four pillars of TD and their characteristics.
Source: Author (2013) adapted from Pohl & Hirsch Hadorn (2007)

As already stated openly, no specific research framework was present initially, but the aforementioned principles of TD helped to guide the process. The principles formed part of an unconscious awareness and tacit knowledge that was embedded into the methodology. By reading TD literature at the beginning of the research process, the principles, concepts and overall intent of TD was absorbed and this was subsequently embedded into the approach. An insightful working paper by Sabina Andrén (2010), a PhD candidate at Lund University (in 2013), was used as an aid to express the more implicit properties of TD that were found to be most relevant for this research. According to Andrén (2010), some prominent characteristics of TD are ‘communication’, ‘open-mindedness’, ‘innovation’ and ‘creativity’.

In support of TD’s third principle of open encounters (Pohl & Hirsch Hadorn, 2007), Stokols (2006) writes of the requirement of an ethic that is tolerant, open and respectful to perspectives different to one’s own, and a commitment to mutual learning in which conflicts of interest and contrasting values are negotiated and accepted. Furthermore, in accordance with the second principle of contextualisation, a TD researcher has to embed herself in various types of communication processes within the academic arena, political arena, in public discourse as well as in informal settings (Andrén, 2010). Most importantly, and as was

stated in Section 1.6.2, the researcher must not see herself in a position of superiority or as someone with privileged knowledge. Hoffmann-Riem, Biber-Klemm, Grossenbacher-Mansuy, Hirsch Hadorn, Joye, Pohl, Wiesman & Zemp (2008:4) state succinctly that "TD research should be a consistent reaction against the view of a 'one-way transfer of allegedly reliable instrumental knowledge from experts to 'ignorant' users".

Andreas Keller, who completed his Master's research with the ISUG the year prior to this study, states in his thesis (Keller, 2011a) that one of the primary influences on his research design was the following quote from Wickson *et al.* (2006):

> ... the contribution of research to the solution of these problems will not be answers to the conceptual puzzles, but rather practical outcomes that can be applied in a social or environmental context and which therefore bring about some degree of change in those contexts.

Similarly to Keller, the intention of this study was to achieve a practical outcome through research, and something that ideally would have a positive and lasting effect in practice, rather than only making a theoretical contribution. Thompson Klein (2008) confirms that this is a possibility that TR affords the researcher when he writes that TD research is not only curiosity driven, but also invested in improving the lives of people struggling with problems of the life-world.

To have such goals of improving the lives of people as a direct impact of one's research is ambitious and not always possible. Furthermore, focusing on problem and solution-oriented research in real-world contexts often invites critique from the scientific community on the quality of the research and the possibility to generalise the findings (Andrén, 2010). In TD different starting points and working methods inevitably lead to another kind of result, reducing generalisability (Andrén, 2010). For example, had a strict methodological approach been adopted from the beginning of the research process, certain opportunities like setting up a pilot project in Enkanini may never have materialised, thus affecting the end results of the study. Outcomes of such research are usually unlike 'traditional' scientific results (Andrén, 2010) as the TD mode of problem framing and conducting research leads to results that do not constitute objective, generalisable knowledge.

In the same breath, one may criticise the objectivity of the researcher conducting TR, as she is asked to embed herself so deeply into the context of the study that objectivity becomes a far-fetched notion (Andrén, 2010). However, to counter this, one may also question the

objectivity of traditional science, as it has been conducted in the past. Descartes and Galileo were founding fathers, so to speak, of the belief that in science lies an unquestionable truth and objectivity. Whether traditional science still delivers this certainty and whether it is still believed unquestioningly that science is free of personal judgements, values or institutional agendas is debatable (Funtowicz & Ravetz, 2008). However widespread this belief may still be, when scientists are removed from the life-world, separated from a world of subjectivity, unreliability and irrationality, the very obstacles that make problems of the life-world so complex, are also removed. And these are precisely the problems that need to be researched. By placing scientists in a separate sphere of objective higher ground, the gap between science and the life-world becomes entrenched to the point where theory and implementation are completely estranged from each another. To conclude, this study does not claim to be objective, as I immersed myself deeply into the life-world problem in an attempt to provide real solutions.

1.8 A retrospective framework

The following paragraphs outline the TD framework, which was placed onto the research process retrospectively – in the same reverse manner, one could say, as when one would build a solid structure around an already existing interior to complete a house. In this way, the necessary flexibility was present to design the 'interior' the way it was believed to be most suited in ever-changing circumstances and fluctuating conditions of the life-world as the research process unfolded. In this way, opportunities such as the engagement with actors, the pilot project, the waste characterisation study, etc. could be incorporated into the process, rather than having to fit these "interior" aspects into an already existing structure or framework.

Similar to building a house backwards, the research was like having a few pieces of furniture that one arranges in the first phase, and then proceeding to build the walls around the furniture to create actual rooms in the second and third phase. The furniture represents the actors, scenarios and methods of the study, or also what is termed 'communication processes' (see Chapter 3). As the research progressed, elements were added to the collection of furniture and these were rearranged as was necessary given the circumstances at that time in the life-world. In this way, the process continuously stayed in a "context-informed" research mode, as Wickson *et al.* (2006) refer to it. Some of the actors of the life-world who became stakeholders (specifically the co-researchers), were involved in figuratively arranging and rearranging the 'furniture' until it was agreed that an outlay had been achieved that was

acceptable to most, and hence satisfied the TD principle of 'the common good' (Pohl & Hirsch Hadorn, 2007). This was all done without the figurative exterior 'solid wall', or framework. The research process was thus not constrained by solid structures, such as the figurative room that dictates how many pieces of 'furniture' one can place into it or which way the pieces needed to be oriented. The 'furniture' could be manoeuvred in an easier and much more flexible manner, enabling the process to respond to fast changing real-world situations.

However, as mentioned before, upon reflection on the 'furniture' arrangements that had been created through the research process, the careful and deliberate arrangement and placement still looked very random and haphazard to an observer that had not been part of the process. This contributed to the realisation that only a solid structure, such as the figurative wall, would give the furniture arrangement a meaningful appearance that would make it accessible and understandable to any observer; everyone can recognise a house with walls, but a house with no walls is confusing and can seem chaotic. The walls give it structure and ground it in the earth through a concrete substance that also supports the structure and upholds it under pressure. This symbolises the figurative framework that lends support and structure to a research study, and that gives it academic robustness.

The figurative walls that were placed around the furniture arrangement are representative of the TD framework that will be explained in detail in the following section.

There are many approaches that fit within TD research methodology, such as, but not limited to, participatory and action-oriented approaches, the embedded case study approach and the phronetic planning research approach, as outlined by Flyvberg (2004). Each approach outlines different methods and frameworks within which the research process could be positioned. Although these various approaches are relevant TD frameworks of which any could have been adopted in this study and its prescribed methods followed, Wickson *et al.* (2006) encourage scientists to adopt pluralistic methodologies in order to avoid methodological reductionism. Wickson *et al.* (2006) suggest that there can be no single TD research methodology as the TD research process does not lend itself to that. The process should rather be a context-informed reflection of the relevant problems and therefore needs to be more flexible and inclusive of multiple methodologies.

In this case, the research approach was inspired and informed by the overall intent and principles of TD, but did not conform to one particular approach, neither at the beginning,

nor at any other point during the research process. Retrospectively, one is able to find similarities in intent amongst many of the aforementioned approaches and the approach used in this study, but these overlaps happened organically without the conscious intent to follow a specific approach. Hence, the research process was neither determined by a certain approach, nor was it bound to a specific framework.

However, on completion of the field research and upon reflection of the process it was difficult to coherently present the findings and describe the research process. Reflection and analysis showed that the study was successfully contextualised within the life-world during the first part of the research process, but it had not been contextualised within a particular framework that would allow for a comprehensible description of what had transpired. This realisation led to the insertion of a TD framework ex post facto, to put into words this very organic and non-linear research process.

1.8.1 Outlining the framework

The framework used in this study, which enabled me to coherently write up the research, is one established by Pohl & Hirsch Hadorn (2007) in the book *Principles for Designing Transdisciplinary Research*. Chapter 4 in their book outlines three main phases that a TD research process falls into. These phases are (1) problem identification and structuring, (2) problem analysis and (3) bringing results to fruition (see Figure 1.6). Each phase also corresponds to a particular form of knowledge which Pohl and Hirsch Hadorn (2007) have termed 'systems', 'target' and 'transformation' knowledge. Systems knowledge concerns itself with questions about the genesis of a problem and how these are interpreted in the life-world (Pohl & Hirsch Hadron, 2007), i.e., "What do we have currently?" Target knowledge concerns itself with questions that are related to the need for change and that determine what the desired goals and better practices are, i.e., "What do we want instead?" Lastly, transformation knowledge concerns itself with questions about the means to change existing practices to lead to new, desired practices, i.e., "How do we get there?" The three research phases and these corresponding knowledge forms set the outline of the framework that was retrospectively placed onto the research process. This section explains each phase first in theoretical terms, which is considered the ideal TD process, followed by how each phase unfolded in practical terms.

As already mentioned above, the overall aim of the research was to contribute to increasing the sustainability of the waste system in Enkanini. This aim informed all three phases, although the aim for the first and second phase specifically, was to facilitate connections and

translate perspectives to move from systems and target knowledge to transformation knowledge, and thus to transform existing practices into new, desired ones. The overall aim and more specific aim are to be kept in mind while reading through the phase development described in the next few paragraphs.

Although the literature draws a distinct line between the various phases, it is difficult to find a point in time that marks the end of one phase and the start of another, as certain processes and actions overlap in the various phases. However, for the purpose of a framework, the structure and outline of the three phases will be followed as closely as possible.

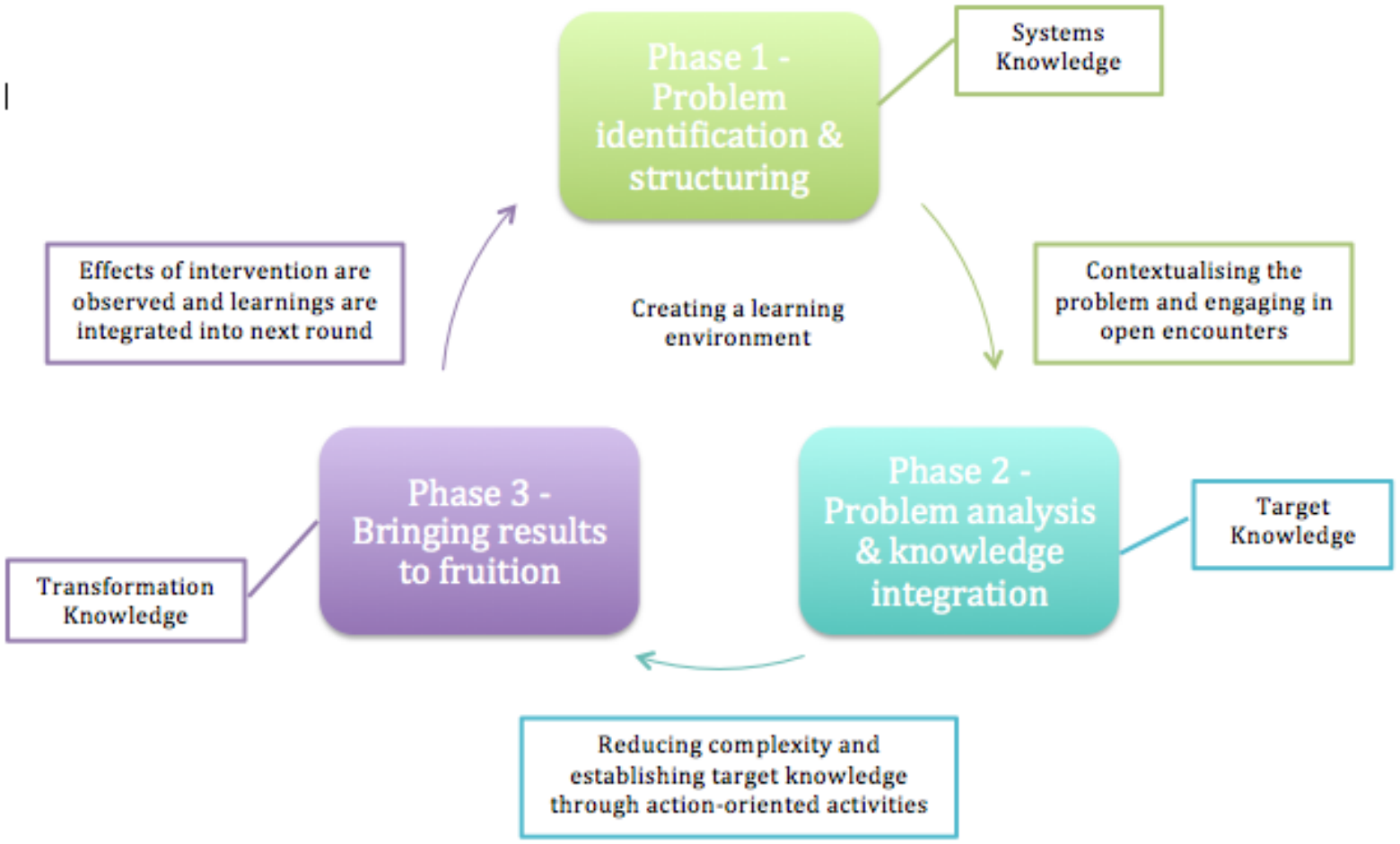


Figure 1.6 The three phases of a TD research process and corresponding knowledge paradigms.

Source: Author (2013) adapted from Pohl & Hirsch Hadorn (2007)

1.8.1.1 Phase 1: Problem identification and structuring – systems knowledge

a) Theoretical outline

At the heart of TR lies problem identification and structuring, as Pohl and Hirsch Hadorn (2007) posit. The process in this phase is encouraged to be executed creatively and with originality, as it has the potential to bridge the infamous gap between science and practice, to build a bridge between fixed viewpoints by, for example, finding new ways of perceiving things (Pohl & Hirsch Hadorn, 2007).

During the first phase of framing the research process, the researcher is therefore required to contextualise the research problem within the life-world and within relevant scientific disciplines. For Pohl and Hirsch Hadorn (2007) contextualisation means to build on existing disciplinary and life-world perspectives of the problem and structuring the problem means to position it in such a manner that enables the exploration of its complexity relevant to practice-oriented solutions. These actions are performed in pursuit of what is perceived to be the 'common good'. Embedding TR in science and in the life-world context effectively links abstract knowledge to experiential knowledge with the aim of contributing to practice-oriented problem solving (Pohl & Hirsch Hadorn, 2007). A researcher can achieve this by involving relevant disciplines and establishing relations with relevant stakeholders.

Contextualisation alone often leads to a reformulation of the research question in relation to the life-world actors (Pohl & Hirsch Hadorn, 2007). Problems that had been previously identified from a scientific perspective need to be related to specific circumstances and to the actors involved, and this may lead to a rephrasing of the research question, and possibly the entire research problem. Also, through contextualising the problem, the complexity thereof can be reduced simply by identifying stakeholders and by specifying the need for knowledge (Pohl & Hirsch Hadorn, 2007).

This phase also mainly concerns itself with systems knowledge. Systems knowledge is about establishing what the status quo is and refers specifically to the process of "describing, analysing and interpreting empirical processes that influence problems" (Hoffmann-Riem *et al.*, 2008:4).

In this research process this phase took on the following shape:

b) Practical application

The initial proposal to conduct research on waste management was problem-oriented in that the proposal focused on attitudes and behaviour towards waste management in Enkanini. As

the study was contextualised within the life-world by embedding the perceived problem into the context of Enkanini, the problem itself was reformulated in relation to the life-world actors and thus became more solution-oriented. Instead of the initial idea to focus on behaviour towards waste, the research was redirected to question what workable alternatives to the current waste management system are possible to achieve within the given time constraints as well as taking into account external constraints such as financial and human resources.

The context of the study included Enkanini and its respective political structures, the history of a tense relationship between Enkanini and the municipality around service delivery for the settlement and the broader context of Stellenbosch and the ISUG. Relationships were established with people from the community itself as well as municipal officials and private sector representatives as the research approach was heavily influenced by the principle of open encounters, as described above. Hence, a solid network of actors within the life-world was constructed. This allowed the exploration of the problem of waste management in Enkanini as seen from various perspectives.

The following questions were developed during the course of the first phase to contextualise the problem and reduce its complexity, while simultaneously integrating systems knowledge between and across actors and communication processes:

1. What are the problems with the current waste management system in Enkanini that are of social, environmental and economic concern, and what is the broader context, on a town level, within which it is embedded?
2. What kind of waste is being generated in Enkanini?
3. What are some of the alternative waste management (treatment) systems for low-income areas and informal settlements that are being implemented by municipalities, the private sector and civil society organisations in South Africa?

The first two questions both served to establish the status quo in Enkanini. The first question specifically served the purpose of identifying the main problem as seen by various stakeholders as well as contextualising it in the local setting. The second question served to reduce the complexity of the overall problem of general household waste by narrowing it down to one particular category of household waste, namely food waste. Lastly, the third question helped contextualise the problem within the broader South African setting. The methods used for this phase will be expanded upon in Chapter 3. The findings based on these

questions (see Chapter 4) enabled a reformulation of the original problem-oriented research question to a solutions-oriented research question, which is framed as follows:

What are some alternative waste management systems that are imminently implementable in Enkanini and that will contribute to improving social, economic and environmental sustainability of the waste management system?

Once the real-world problem had been recognised and the main research question had been established, the literature posits that this signals the end of Phase 1 and the beginning of Phase 2 (Pohl & Hirsch Hadorn, 2007).

1.8.1.2 Phase 2: Problem analysis and knowledge integration – target knowledge

a) Theoretical outline

The intent of this phase is to collaborate with various stakeholders and to integrate different knowledge sets with the purpose of increasing shared understanding (Pohl & Hirsch Hadorn, 2007). Phase 2 consists of three steps. First, the research question is divided into sub-questions or sub-problems. Second, the sub-questions are dealt with and answered by each stakeholder independently, while keeping them interrelated. Third, the various sub-answers, or results, are then integrated. The authors make a distinction between four forms of collaboration to achieve this, namely common group learning, negotiation amongst experts, integration by leader and modelling. The forms of collaboration refer to the organisation of group work, in other words how the researcher chooses to coordinate stakeholders for collaboration.

As explained in TD literature, this phase evolves democratically in an almost 'round-table' manner where stakeholders divide the sub-questions amongst themselves, consider them independently and then present their findings from their specific perspectives (Pohl & Hirsch Hadorn, 2007). The various answers to, or perspectives on, these questions are then pooled and integrated, aided by various modes of integration, to arrive at a proposal for a life-world intervention. A mode of integration is a tool used by the researcher to integrate the different knowledge sets that arise from the collaboration (Pohl & Hirsch Hadorn, 2007). The process can take on variations depending on which form of collaboration is being used, but the underlying intent is to give each stakeholder a chance to present their own perspective in an open encounter and to integrate the numerous perspectives through one or numerous modes of integration.

According to Pohl and Hirsch Hadorn (2007) modes of integration are important, because various stakeholders will have various perspectives on the problem, and in order to fully integrate these perspectives it is necessary to relativize one's own perceptions while accepting that other viewpoints are equally relevant. To assist us in relating different perceptions to our own we can make use of various modes of integration, for example through the use of a glossary, a boundary object, models or even everyday language. These are elements that a researcher uses to help integrate knowledge and perceptions amongst various stakeholders, because these elements are common to all and can be used as a vehicle through which to communicate with stakeholders in different realities.

b) Practical application

The form of collaboration that was used during this research most resembled what the literature outlines as 'integration by leader' (Pohl & Hirsch Hadorn, 2007). The integration by leader model does not require each stakeholder to reach a deeper understanding of all the other perspectives, as it is left up to the leader to integrate various perspectives. In this study it was not necessary for the co-researchers to reach a complete shared understanding of the problem as seen by the municipality or vice versa, and the understanding could be kept to the minimum, for example understanding certain constraints that directly affected the objectives of the pilot project.

I, as the researcher, took on the role as project leader and met with many stakeholders and actors as individuals or groups to explore their perceptions of the problem. The two main stakeholders of this project, namely Enkanini residents and Stellenbosch Municipality, i.e. the solid waste department, never met directly to discuss possible ways forward until after the pilot project had ended.

Further, it was not necessary for the co-researchers to gain an in-depth understanding of the financial and political pressure the municipality faces regarding service delivery and infrastructure backlogs. Nor was it necessary for municipal officials or myself to gain an in-depth understanding of the behaviour of littering among some Enkanini residents (something I have observed in many instances), as the mode of integration helped bypass such learning requirements while still moving forward with the same overarching goal of increasing the

sustainability of the waste management system. The boundary object[4], which will also be discussed in Chapter 3, capacitated communication between stakeholders, even without reaching complete shared understanding.

The mode of integration through a boundary object, namely the use of bokashi[5] (the alternative food waste treatment method that was later to be used in the larger pilot project), to which all stakeholders could relate either through abstract or experiential knowledge, was a tool used to bridge any gaps in understanding from different perspectives. The boundary object was established amongst stakeholders in Phase 2 and co-researchers started using bokashi before the implementation of the pilot to gain in experiential knowledge. This enabled them to give feedback on the bokashi method. Saliem Haider at Stellenbosch Municipality was the first to suggest bokashi as an alternative method, and was able to relate to bokashi through abstract knowledge, whereas experts on bokashi as well as me as the researcher were able to relate to it both in abstract and experiential terms. The product and the use of bokashi thus became the common factor between these stakeholders during Phase 2. However, the biggest group of the stakeholders, which are the Enkanini residents, were only exposed to the boundary object in Phase 3 during the implementation of the pilot project. In this way, the boundary object was a commonality in both Phase 2 and Phase 3, making it difficult to draw a line between the two phases and allocate certain actions to each of them individually.

Phase 2, introduced by the research questions that emerged in Phase 1, included exploring various alternative waste management options for Enkanini, such as a community collections model pioneered by a private company called Tedcor (Pty) Ltd (deriving its name from The Entrepreneurial Development Corporation), as well as other models focusing on recyclables, such as TrashBack (these options will be detailed in Chapter 4). Explorations consisted of semi-structured interviews and field trips, alone and with the co-researchers. However, the explorations of various alternatives was narrowed down dramatically when a life-world

[4]A boundary object is any object to which all actors involved in the study/project can refer based on their specific interest in shaping things and thus allows for a common understanding to emerge without requiring explicit communication between the various perspectives of different actors (Pohl & Hirach Hadorn, 2007).

[5] Bokashi is a substrate, most commonly wheat bran mixed with a certain percentage of molasses and water, inoculated with effective miocroorganisms. The microorganisms are mostly lactic acid bacteria and when the substrate is sprinkled over food waste, these bacteria assist in decomposing the organic matter through a fermentation process.

opportunity presented itself: Stellenbosch Municipality, specifically the solid waste department, proposed a pilot project around food waste using bokashi and consequently the study was to concentrate on this one particular alternative. Hence, even though the main research question addresses alternative food waste systems in the plural, the exploration was eventually only focused on an in-depth examination of one particular alternative, simply because the opportunity to do so in the life-world arose. This means that the main research question would not be answered in entirety, but only in part, as only one alternative was thoroughly researched. This creates the opportunity for additional explorations of various alternatives in further research projects.

Hence, the practical application of Phase 2 differed substantially from its theoretical outline. The literature regards dividing the main research question into additional sub-questions, which would then be considered by each of the stakeholders independently, as the ideal TD process to arise to an integrated intervention proposal. It was decided, rather, to pursue the life-world opportunity of implementing a pilot study that focused on one alternative. This was done for numerous reasons. The first reason is that the municipality was willing to take on the costs of the project and was enthusiastic and ready to start immediately. Their proposal indicated that they were willing and open to finding alternative solutions to the waste problems in Enkanini. In South Africa, municipalities do not often take the initiative and run with it as Stellenbosch Municipality did, either because they are not in a financial position to do so, or because they are incapacitated due to inefficiencies or corruption in the system (Goldman, 2012). Therefore, the proposal for a life-world intervention already took place in Phase 2 rather than how the literature outlines it as typically occurring in Phase 3.

The practical application differed further from the theoretical outline in that the proposal to implement a pilot project focusing on food waste and using bokashi came specifically from one life-world actor, namely Haider, the manager of the solid waste department. The proposal was made soon after the municipality conducted a waste characterisation study that found food waste to be the most prominent waste stream in Enkanini (see Figure 4.10 and Figure 4.11). This may be grounds to criticise the research study by suggesting that the intervention was stipulated solely by one life-world actor and is therefore not representative of the other stakeholders' perspectives. The ideal that TD literature puts forward is to work inclusively with all stakeholders and to offer a representative methodology in which all stakeholders' perspectives are integrated in such a way that a truly integrated solution to the life-world problem emerges. This may be an attainable goal in the global North where one can assume

that stakeholders hold equal power of engagement and often also have formal institutions backing them, but this does not always hold true for the global South where power balances between stakeholders are more uneven and where there are no strong intermediaries to represent those with less power (Keller, 2011b).

Given the power imbalances in these research circumstances, it was necessary to mould the research process into this context. As stated above, the municipality, which is a relative heavyweight in terms of power of engagement, was eager to pilot a possible alternative food waste treatment method. Therefore, it was decided, with agreement from the ISUG and the study supervisor, to make use of this opportunity, as the municipality's willingness to engage was valued highly. Having noted that, this alternative treatment method for food waste was never posed as the silver bullet to all food waste, let alone all Enkanini's general solid waste problems. The municipality, as well as this study, positioned the pilot as an experiment from the beginning, with the objective to evaluate its scalability determined by participation, costs, and social and environmental impact. We placed high importance on participation rate and were looking to incorporate participants' feedback into a second stage of the pilot programme. Therefore, the TD principle of recursiveness is applicable here, as knowledge gained from the pilot would be implemented for the next stage of bringing results to fruition (Pohl & Hirsch Hadorn, 2007).

Hence, rather than dividing the main research question into further sub-questions, as the literature stipulates, sub-questions were established that would be answered through the implementation of the pilot project. The intervention point was already decided upon, but with the principle of recursiveness in mind. The sub-questions spoke to the various spheres of sustainable development and were as follows:

Social sustainability:

1. What will the participation rate of the wider community in the pilot project be?
2. What are the benefits and shortcomings of this particular waste treatment method from the perspective of the community?
3. Did social learning take place and does this have an impact on the broader context of Stellenbosch's waste system?

Environmental sustainability:

4. How much food waste can be diverted from landfill through the alternative processing method?

Economic sustainability:

5. What are the costs of the alternative processing method and are these feasible compared to current costs?

1.8.1.3 Phase 3: Bringing results to fruition – transformation knowledge

a) Theoretical outline

This phase, the transformation of knowledge, is a stage in the learning process and should therefore not be seen as the final stage, maintaining the notion of a recursive process (Pohl & Hirsch Hadorn, 2007). Other terms used for this phase include implementation, valorisation, or dissemination of results. Every instance of implementation is seen as an experiment that needs to be observed to learn something for the next instance of implementation. Particularly important in this phase is that implementation of results bridges the gap between abstract research and concrete problem analysis, hence closing the infamous gap between the academic world and the life-world (Pohl & Hirsch Hadorn, 2007).

The recursiveness of this phase, which enables learning for future implementations, allows for the complexity of problems and the diversity of perspectives to be adequately taken into account (Pohl & Hirsch Hadorn, 2007). In this manner, knowledge is increased, as the effects of a project are observed with the intention of finding unanticipated affects. This is followed by a revision of the assumptions, models and explanations developed for the first phase of implementation. Following this, new instances of implementation are planned and conducted.

b) Practical application

The literature refers to Phase 3 as the implementation of results that were obtained in Phase 2, namely that the results of the sub-questions are consolidated to give rise to an integrated solution to the problem (Pohl & Hirsch Hadorn, 2007). Considering that the research process diverged from this outline in Phase 2, Phase 3 has to be adjusted accordingly. Therefore, in this study it was not the results to the sub-questions that were shaped into an intervention, but rather the objective to implement a pilot project on food waste processing that needed to be designed and implemented. The overall aim for Phase 3 was to implement and test an alternative food waste treatment method according to its social, economic and environmental sustainability.

This phase consisted mainly of designing the pilot project in collaboration with the co-researchers, and implementing and managing the pilot project. (see Chapter 2 for a detailed description of the pilot set-up). The pilot project ran for a nine-week period. Towards the end

of the pilot project, a survey was administered to obtain feedback from participants with the intention to incorporate this into the next iteration of the project. After the completion of the pilot project, the outcomes were evaluated and the sub-questions were answered. The overall research question was partially answered in that only one alternative method was investigated in depth. Further alternatives would have to be researched in depth in recursive phases of a different research process.

1.9 Research question and objectives

The previous section embeds the evolution of the research aims, pre-questions, main research question and sub-questions in the relevant context, to let the reader understand the somewhat unusual manner in which they have been established. This section gives a short summary thereof, to highlight the pre-questions, main research question and sub-questions in a linear fashion.

The overall aim of the research study was to contribute to increasing the sustainability of the waste management system in Enkanini.

The aim for Phase 1 and Phase 2 was to facilitate connections and translation of perspectives and knowledge to move from systems and target knowledge to transformation knowledge.

The aim for Phase 3 was to transform existing practices into new, desired ones.

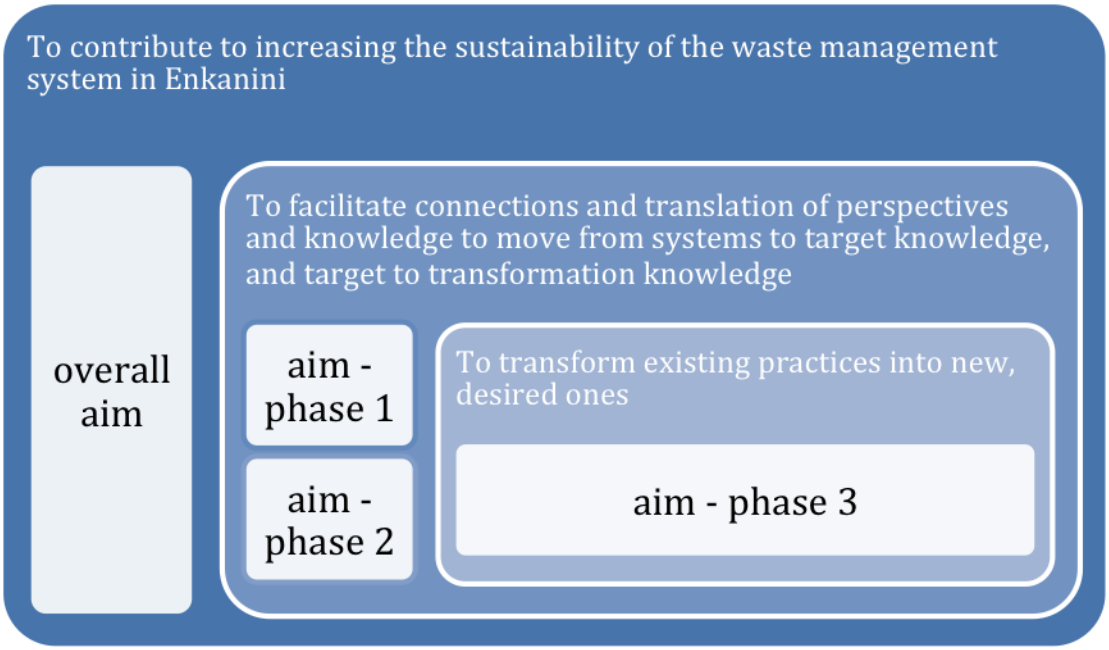


Figure 1.7 The aims of the individual phases embedded within the overall aim of the study.

The preliminary questions are as follows:

1. What are the problems with the current waste management system in Enkanini in terms of social, environmental and economic sustainability?
2. What kind of waste is being generated in Enkanini?
3. What are some of the alternative waste management (treatment) systems for low-income areas and informal settlements that are being implemented by municipalities, the private sector and civil society organisations in South Africa?

By answering these questions, the main research question was established as:

What are the alternative food waste management systems that are imminently implementable in Enkanini that will improve social, economic and environmental sustainability?

Following this, an intervention was decided upon and the sub-questions for the pilot project were formulated as follows:

1. What is the participation rate in the pilot project?
2. What are the benefits and shortcomings of this particular waste treatment method from the perspective of Enkanini residents and the municipality?
3. How much food waste can be diverted from landfill through the alternative processing method?
4. What are the costs of the alternative processing method and are these feasible compared to current costs?
5. Did social learning take place and does this have an impact on the broader context of Stellenbosch's waste system?

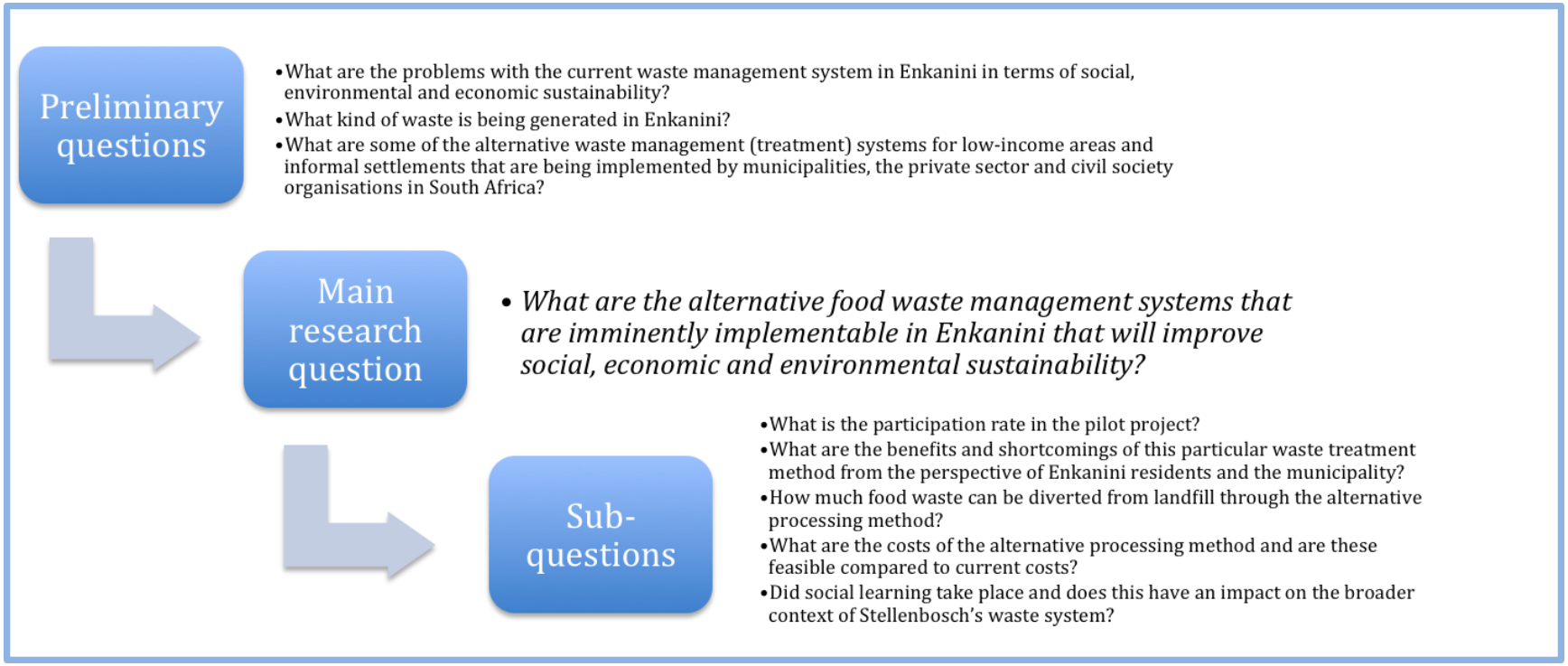


Figure 1.8 The process of identifying the research questions of this study.

1.10 Thesis outline

Chapter 2 of this study is a literature review that contextualises the study within the academic literature of waste management in a social context, as well as literature concerning informal settlement upgrading. The literature review forms part of systems knowledge that populates our understanding of what is already in existence. Systems knowledge will then be populated further through the three preliminary questions that are answered in the Chapter 4.

Chapter 3 describes the methods that were used in this study by providing a detailed account of the three phases that were laid out as the framework in the introductory chapter. The objective of this chapter is to let the reader understand all actions that transpired during the research study.

Chapter 4 lists the findings of the study by systematically answering the questions that were established in the various phases of the research, including the preliminary and sub-questions. The preliminary questions help to populate systems knowledge (Phase 1) and the sub-questions form part of target knowledge. Transformation knowledge was established through the pilot project, but not as yet integrated into the knowledge sets of the various actors and stakeholders. This indicates that a change process has begun, which can transform the existing waste management methods and accompanying behaviours into new, desired ones if the process is nurtured and taken forward through further iterations of interventions.

Finally, Chapter 5 provides the concluding arguments of this TD case study on incrementally improving the solid waste management system of an informal settlement. Further, it is determined to what extent the main research question has been answered. Lastly, this chapter lists additional areas that require further research.

Chapter 2 Literature Review

2.1 Introduction

> Waste management has for quite some time been understood as a key area in global environmental protection. Beyond that integrated waste management may be regarded as an interface between the production, distribution and consumption of goods on the one hand, and soil, groundwater, air and climate on the other. Thus, it is an important partner in the context of sustainable development – Christoph Scharff (2002), President, International Solid Waste Association.

Waste is a very broad category that encompasses a vast range of terms and definitions. Waste can be called by various names such as trash, dirt, rubbish, refuse, litter, debris, junk, garbage or scrap. In terms of waste management, waste can either be classified as municipal solid waste, also known as household or domestic waste, hazardous waste (including healthcare waste), industrial waste, or e-waste (electronic waste) (Bergmann, 2002). However, what constitutes waste is often a subjective notion (Drackner, 2005). Mary Douglas, a British anthropologist specialising in social anthropology and well known for her writings on human culture and symbolism, defined waste in her book *Purity and Danger* simply as "matter out of place" (Douglas, 1966).

The many terms and categories for waste and Douglas's broad definition of waste give testament to the subjective nature of it. Waste is a relative idea, and what waste constitutes, depends on your culture and point of view (Zimmermann, 1988). In line with the definition of waste as "matter out of place" (Douglas, 1966), it can be deduced that waste, rubbish or trash are dynamic categories and therefore elude any objective (and concrete) definition (Drackner, 2005). What one person may view as useless, and therefore as waste, may be viewed as valuable by someone else. Strasser (1999) sums this up clearly by saying "what counts as trash depends on who's counting".

If the philosophical trajectory of the above is followed, one would have to conclude that there really should be very little 'waste' in the world that is universally regarded as useless. Most objects still have some value, whether it is to a recycling company or a waste picker or simply to your neighbour. Regrettably, this value is becoming more and more obscured and difficult to harness. The value of an object that is classified as waste by some essentially lies in its reusability or recyclability. However, the dominant design of modern manufacturing,

ever since the industrial revolution, is based on a cradle-to-grave model, which gradually and unintentionally led to the creation of more waste (McDonough & Braungart, 2002). A cradle-to-grave model is a manufacturing design model in which products, already during their conception phase, are simply not designed with the thought of reuse or recyclability, but rather designed in such a way that disposal is the ultimate termination of the product's lifecycle (McDonough & Braungart, 2002). This means that until the fundamental underlying manufacturing design processes of our modern industrial systems are redesigned from a cradle-to-grave model to a cradle-to-cradle model, waste (which is universally classified as having no value) will continue to be generated. No matter how much the mantra "reduce, reuse and recycle" is preached or even instituted in policies and laws, it will remain a futile effort because reducing, reusing and recycling are all end-of-pipe solutions that address the symptoms but not the cause (Engledow, 2005).

Be that as it may, this thesis does not address the fundamental problem of waste creation through product design. Instead, it is assumed that manufacturing processes and product design will not change drastically in the near future and that waste will continue to exist, and therefore that waste needs to be managed in a sustainable manner in order to minimise its impact on the earth. This is accepted as a rigid point of departure to explore alternative waste management systems that optimise reduction, reuse and recycling within the boundaries of the current overall industrial system. Following, is a review of waste and how it fits into sustainable development, as well as what implications it has for the poor. Part A describes the social history of waste and where we find ourselves today with regards to waste generation and waste management practices. Part B is a short overview of the South African Housing Policy and the UISP, and how they relate to service provision and specifically waste management. The notion of participation in the upgrading process is explored in further detail.

Part A

2.2 A social history of waste

Humans have been discarding undesired items considered as useless even before the industrial revolution brought about the entrenchment of the aforementioned cradle-to-grave production system. Archaeologists have found historical evidence that suggests humans have always thrown out unwanted objects, whether this was broken clay pots or food waste (Strasser, 1999). Since then, what has changed drastically is the kind of waste that we discard. Whereas before these undesired items would have broken down and biodegraded more easily, undesired items today are of a different chemical make-up which hinder or drastically slow

down the biological breakdown (Strasser, 1999). Considering our cradle-to-grave design process, which is indicative of waste creation (McDonough & Braungart, 2002), 'zero-waste-to-landfill' is a commendable, yet unrealistic, goal if fundamental manufacturing design processes are not rethought and remodelled.

Along with the paradigmatic shift regarding manufacturing processes that the industrial revolution embodied, our attitude towards, and interaction with, waste have also changed. What has radically changed over the last century is *what* objects we classify as unwanted, our notions of waste, how much of it we throw out and how we cope with it (Strasser, 1999). Strasser, a historian of American consumer culture, has documented the social history of trash. Although her analysis is of the American culture, it can be assumed that the history of social interaction with waste is similar in other Western countries around the world (or countries that industrialised at the same rate as the United States).

For centuries cities had problems with garbage that was being dumped on streets and sidewalks, as people were used to throwing kitchen refuse out the front door or window, which was the norm in countryside towns and villages (Strasser, 1999). As cities grew and became denser, the garbage that piled up on streets became increasingly problematic. However, before the turn of the 20th century it was customary, and feasible from a product design point of view, to reuse most household items (Strasser, 1999). Household manuals and guides advised of various ways to reuse different objects in different manners, for example virtually every manual had recipes and techniques for mending glassware and crockery. Strasser (1999) terms this behaviour the "stewardship of objects". This stewardship was also visible in the many processes that were recommended to protect new possessions and prolong their useful lives (Strasser, 1999). Prolonging an object's life was also due to the thriftiness present in 19th century housekeeping (Strasser, 1999). This period could be described as the era of the bricoleurs – people who created things from diverse objects and material, depending on what was currently at hand.

In terms of our attitude towards waste, the custom of stewardship[6] was slowly abandoned in the early 20th century (Strasser, 1999). Reuse and recycling not only became old-fashioned but was also associated more and more with the poorer classes, as individual wealth increased. Industrialisation and the dawn of consumerism brought with it material wealth as well as

[6] Stewardship is defined here as a habit of thrift in which household items are repaired and amended in a continuous cycle of reuse, leading to minimal wastage (Strasser, 1999).

wastefulness. Thorstein Veblen, a 19th century economist and sociologist, theorised that discarding things was a demonstration of power and wealth, terming it "conspicuous consumption" in his *Theory of the Leisure Class* (Veblen cited in Strasser, 1999). The disposability of items was promoted, right from the beginning, for its ability to make people feel rich, as these products could help one achieve a level of cleanliness and convenience that was once only attainable by those who could afford servants (Lynch cited in Strasser, 1999).

Mass production and mass distribution literally generated more stuff, and hence more waste (Strasser, 1999). Along with this came the age of advertising, which in its own right generated unprecedented amounts of paper waste. Advertising meant that products were no longer sold for just their content but also for their packaging, and thus branding became an integral part of the sale (Strasser, 1999). Spurred by not only consumerism but also capitalism, products were increasingly being designed to lose their value quicker and last a shorter period of time. This meant that people would have to throw these products out, sooner rather than later, and buy a replacement (McDonough & Braungart, 2002). In an ideological analogy one could describe this change as households, and even cities, going from closed systems to open systems or a cradle-to-grave system. Leftover food, which was once fed to the chickens, now ended up in a garbage bin along with the torn pair of trousers, which once would have been patched or converted to trousers for a child. What once would have been reused in the same household was now being thrown out and taken away to incinerators or landfills. (McDonough & Braungart, 2002).

As consumerism developed and the amounts of household waste grew, local authorities started taking on the responsibility for collecting and disposing of household waste, which made it easier to throw things away as the waste now became the city's problem (Strasser, 1999). The middle class learned to throw things into the dustbin, which was an attractive and convenient option, while reuse and recycling became associated with a new class of impoverished scavengers (Strasser, 1999). Although officials and reformers concerned about public health had been trying for centuries to get the streets of American cities cleaned up, it was only towards the end of the 19th century, in the Progressive era (a movement started in the United States of America between 1890 and 1920 that saw a wide range of economic, political, social and moral reforms), that the movement for sanitary improvements really gained traction (Strasser, 1999). By the turn of the century some form of municipal waste service had been established in most American cities, at which point it had become an absolute necessity as waste was being generated on a scale never known before. This had to

do with a rapidly growing population but also with the middle-class generating more waste per capita than ever before.

2.2.1 Waste in the era of consumerism

About a century later consumerism is still booming and finding a sustainable solution to waste management is still an area of contention. In the 21st century an American citizen, for example, is estimated to throw away about 15 tonnes of plastic and 43,371 aluminium cans during a lifetime (Human Footprint, 2008). The total solid waste that an American will send to a landfill during his/her lifespan is estimated at 64 tonnes. Around the world 694 plastic bottles are thrown away every second, and 11 million glass bottles and 100 million aluminium cans are thrown away every day (Human Footprint, 2008).

An individual living in an industrialised country is, on average, able to consume more than a person living in a developing country and, therefore, also creates more municipal solid waste (MSW). Logically, given our manufacturing designs, a link exists between growth in wealth and an increase in waste (Key Note, 2007). The more affluent a society becomes, the more waste it generates. For example, the United States generated 243 million metric tonnes (MT) of MSW in 2009 (United States Environmental Protection Agency, 2009), while India generated about 42 million MT of MSW in the same year (Government of India Department of Economic Affairs, 2009). About 313 million people live in the United States, while 1.2 billion people live in India (Central Intelligence Agency, 2012). This demonstrates that waste created per capita is far higher in the United States (0.78 tonnes per person per year) than in India (0.035 tonnes per person per year).

The waste that the total world population produces is staggering. In 2006 the total amount of MSW generated worldwide was 2.02 billion tonnes and it was estimated to increase by 37.7% between 2007 and 2011 (Key Note, 2007). The unofficial figures are usually even much higher. The worldwide urbanisation trend implies that cities are producing increasing amounts of waste, which all has to end up somewhere, whether it is an open dump or a landfill. Rio de Janeiro, for example, is home to the biggest landfill in the world, Jardim Gramacho, which receives 7000 MT of garbage each day (Waste Land, 2010). This makes up 70% of all garbage produced by Rio de Janeiro and its surrounding areas. Although the waste pickers of Jardim Gramacho remove 200 MT of recyclable waste per day, the majority stays on the landfill. Once this landfill reaches its carrying capacity, another landfill will have to take its place. Not only are some countries running out of space for further landfills, finding new landfill space is becoming more difficult and more costly (Torbay Council, 2012).

Another problem associated with landfills, especially when waste is not managed properly, is biodegradable waste that produces methane gas, a GHG that contributes to climate change (Torbay Council, 2012).

2.2.2 Waste management in developing countries

The aforementioned figures do not represent all the waste that is generated in the world, as many countries have no systems in place to calculate the waste they generate. In many developing countries open or illegal dumping is still the status quo, which makes calculations of waste volumes even more difficult. Around the world, there are only very few countries that are at the point of fine-tuning their waste management systems (Bergmann, 2002). The majority of countries are still struggling with elementary issues such as implementing sufficient collection services for all citizens, while at the same time facing the challenge of increasing waste amounts due to urbanisation trends. These countries also lack financial and technical resources to safely manage solid waste, which often means that final disposal of waste is a matter of transporting it to the nearest open space to discharge of it. In most Indian cities, for example, open dumping is common practice (National Solid Waste Association of India, [n.d.]). An open dump, from here on referred to as an illegal dump, is defined as "a land disposal site at which solid wastes are disposed of in a manner that does not protect the environment, [is] susceptible to open burning, and [is] exposed to the elements, vectors, and scavengers" (National Solid Waste Association of India, [n.d.]). Illegal dumps pose a high probability of adverse effects on health and the environment.

Not only do inadequate waste services lead to unpleasant living conditions and a polluted, unhealthy environment (Department of Environmental Affairs, 2010), but an illegal dump is often easily accessible to people and consequently put people at risk. These dumps are particularly hazardous to children who are vulnerable to the physical and chemical risks that an illegal dump poses (National Solid Waste Association of India, [n.d.]). Poisoning and chemical burns are a risk, as well as exposure to methane gas. Illegal dumps also attract insects, rodents and other vermin. If there is any stagnant water accumulated in the dump it is a perfect breeding ground for mosquitoes, which can multiply 100 times faster than usual due to the warm, ideal conditions present in the dump (National Solid Waste Association of India, [n.d.]). Rats are attracted to the food waste in dumps and multiply at a similarly rapid rate.

Another adverse effect of illegal dumping is water pollution due to runoff from the dumpsite, which contaminates wells and other potential drinking water (National Solid Waste Association of India, [n.d.]). These dumps can also impact proper drainage of runoff water,

possibly causing flooding and land is permanently or temporarily lost due to soil contamination. Another problem is a lack of education and awareness, which means that communities often do not understand the adverse impacts on the environment of dumping and then burning the garbage in an effort to get rid of it. Burning waste emits further GHG and the open fire can spread easily and affect nearby residences (National Solid Waste Association of India, [n.d.]).

Waste management, therefore, faces many challenges in all parts of the world. The United Nations Department of Economic and Social Affairs under the Division for Sustainable Development recognises that "environmentally sound waste management is amongst the environmental issues of major concern in maintaining the quality of the Earth's environment…" (United Nations Department of Economic and Social Affairs, 2009). However, as was mentioned above, while some developed nations are looking for ways to fine-tune their waste management systems in terms of the waste hierarchy,[7] developing countries are still facing challenges of basic waste management, such as rolling out collection services to all citizens.

2.2.3 Overview of waste management in South Africa

In South Africa the historical backlog of waste services, especially for urban informal settlements, tribal areas and rural formal areas, has created similar problems of illegal dumping (Department of Environmental Affairs, 2010). A growing population and economy means that waste volumes will increase in coming years, adding pressure on waste management facilities, which are already in short supply (Department of Environmental Affairs, 2010). In 2011 South Africa generated 9.6 million tonnes of domestic waste (Nahman, De Lange, Oelofse & Godfrey, 2012). At this rate, landfills are reaching carrying capacities dangerously fast with no extra landfills in place to take on the increasing volumes of waste (Houghton, 2012). Levels of capital investments and maintenance are limited or declining, while waste management is pervasively under-priced (Haider, 2012), which indicates that waste management is not fully appreciated by consumers or industries (Department of Environmental Affairs, 2010).

Meanwhile, the historical backlog of waste services mentioned previously has led to unpleasant living conditions, and unhealthy and contaminated environments. Although

[7] The waste hierarchy refers to the various waste management options in increasing order of their environmental impact, namely reduce, reuse, recycle, recover and landfill.

recycling has been recognised at both national and local government level as an important strategy to divert valuable resources being sent to landfill as waste, there is a need to implement new strategies and add further momentum to make current recycling initiatives more effective from an economic and environmental perspective (Engledow, 2005).

The Constitution of South Africa Act 108 of 1996 (Republic of South Africa, 1996), Section 24, the Bill of Rights, states that:

Everyone has the right –

a) to an environment that is not harmful to their health or well-being; and
b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –
    i. prevent pollution and ecological degradation;
    ii. promote conservation; and
    iii. secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

According to Engledow (2005), this sets the baseline for the protection of human and environmental health. There are also legislative and policy documents in place to regulate waste management in South Africa. The National Waste Management Strategy (Department of Environmental Affairs, 2010), for example, requires all local authorities to develop an integrated waste management plan and promote the prevention, minimisation and recycling of waste in accordance with the waste hierarchy. However, there are still some fundamental gaps in the implementation of these plans, such as political and citizenry will to make the shift, as well as financial structures to support minimisation and recycling. The more intrinsic problem that was discussed in Section 2.1 namely the underlying paradigm shift needed to reposition waste management from the 'end-of-pipe' treatment ideology of waste (spurred by the cradle-to-grave design process) to the actual prevention and minimisation of waste products (by adopting a cradle-to-cradle design process) is also not addressed by the waste management plan (Engledow, 2005; McDonough & Braungart, 2002).

2.2.4 Waste and poverty in South Africa

South Africa has a population of 50 million people (Statistics South Africa, 2011), of which at least 10% recorded live in urban informal settlements (Misselhorn, 2008), although, once again, the actual numbers are probably much higher than this. Inhabitants of informal

settlements face extreme poverty, and living conditions in informal settlements are challenging due to limited access to basic services such as water and sanitation, threats to livelihoods such as solid waste accumulation, safety and security risks, frequent shack fires and an accumulation of various other health hazards (Misselhorn, 2008).

A common view is that poverty and the environment are inextricably linked, and that the first step to protecting the environment is eradicating poverty (Murad & Siwar, 2008; Ackerman & Mirza, 2001). Murad and Siwar (2008) argue against this belief, stating that there is little evidence of urban poverty being a significant contributor to environmental degradation. In fact, according to them, it is more a case of urban environmental risks causing or contributing to urban poverty. The poor contribute far less to environmental degradation than their middle- and upper-income counterparts. The environmental problems experienced by the urban poor are rather associated with inadequate provision of electricity, waste collection services, health care services, water and sanitation services and drainage (Murad & Siwar, 2008). Any harm caused to the environment through the lack of such services can therefore be greatly reduced simply by providing the relevant services and infrastructure.

Further, low-income groups generate less waste per capita than middle and high-income groups. In South Africa, low-income groups generate 0.41 kg of domestic waste per person per day, compared to their more affluent counterparts who generate up to 1.29 kg of waste per person per day (Nahman *et al*., 2012). Poor communities in South Africa often do not have proper functioning waste services, especially those communities living in informal settlements (Department of Environmental Affairs, 2010). These communities may generate less waste per capita, but because of insufficient waste services the impact on the environment is still a serious threat. This threat more directly impacts low-income groups as it affects their immediate living conditions.

As posited above, any environmental harm caused by solid waste in these poor communities can be reduced substantially simply by providing waste services and infrastructure (Murad & Siwar, 2008). However, the general waste management services in developing countries, in which most informal settlements manifest, are also not sustainable and are a threat to the environment in themselves (Bergmann, 2002). Therefore, simply providing services and infrastructure in a ‘business-as-usual’ manner, which in the South African context would mean that the majority of the waste would be landfilled without having undergone a separation process, is no solution to sustainable waste management and service provision. Therefore, to summarise, the obligation to provide services to the poor is non-questionable.

However, services cannot be rendered according to the status quo, but need to be sustainable alternatives that provide the same level of service or even an improved level of service while simultaneously honouring the three tiers of sustainability (defined in Section 1.9).

2.2.5 Waste Processing Options

This section gives a short overview of various food waste processing methods that were evaluated through desktop research. Only food waste processing methods are evaluated, as this is the waste stream that the research process was narrowed down to. This process will be explained further in Chapter 3.

The evaluations of the various methods were done according to the criteria of a closed-loop system, in which most waste can be processed locally on-site, thus minimising transport, and where beneficiation of waste can go back directly to the residents of the community. The methods evaluated are composting, processing food waste through anaerobic digesters and using BSFL. Following this, bokashi, the treatment method used in the pilot project of this study, is critiqued and its weaknesses and advantages are listed to indicate how this particular technology was able to work successfully in Enkanini.

2.2.5.1 Composting

Composting methods include vermicomposting, windrow composting, static pile composting and in-vessel composting (United States Environmental Protection Agency, 2009). All of these methods require the right carbon-to-nitrogen ratio in order to break down organic waste (Lampkin, 1990). All of these methods can be done onsite, if conditions allow. However, onsite composting should not be used to process large quantities of animal products or food waste unless it can take place in a controlled environment, as methods such as windrow and static pile composting can create odours and attract pests, if not managed properly (The Official Information Portal on Anaerobic Digestion, [n.d.]). To create a controlled environment, infrastructure is needed and often also high-tech machinery. Windrow composting, for example, is more ideal for large-scale composting and therefore requires heavy machinery (Lampkin, 1990). These methods also usually require a lot of space (Lampkin, 1990) and Enkanini does not have sufficient free space for such composting methods. Furthermore, the heavy machinery needed for these methods is relatively expensive, making onsite windrow or static pile composting a less fitting and desirable option.

Vermiculture or vermicomposting are terms used to describe worm-processing technologies. Vermicomposting is a method whereby organic matter is broken down primarily by worms,

but assisted by other microorganisms (Lampkin, 1990). The most common type of worm used for vermicomposting is the *Eisenia fetida* (*E. fetida*), or red worm (Majlessi, Eslami, Najafi Saleh, Mishafieean & Babaii, 2012), but the *Eisenia hortensis*, or European nightcrawler, and the less effective *Lumbricus rubellus,* or Red Wriggler, are also sometimes used for vermicomposting (Worm composting basics, [n.d.]). These surface-dwelling worms break down organic waste matter by feeding on the microbial community that colonizes the waste material. Worms are sensitive to certain food waste, such as foods high in acidity, so care is required not to throw too much citrus or onions into the worm bin (Worm composting basics, [n.d.]). Worms also cannot process any animal protein such as meats, fats or dairy products, and therefore these food wastes cannot be biodegraded through worm processing technologies (Worm composting basics, [n.d.]). Although vermicompost is very good quality compost, also referred to as "black gold" because it is so high in nutrients, it has its drawbacks in that it cannot compost animal proteins and fats. In the context of Enkanini, this process may not be ideal, as one of the longer-term overall objectives of an alternative food waste management method was to eliminate food wastes, which pose health risks, from lying in the open bays. As only certain types of food waste can be processed by vermicomposting, an additional processing method would have to be implemented for the rest of the food waste categories. Further, having to add another level of food waste separation makes the process less convenient for users as they would have to be careful not to kill the worms by giving them too much acidic food or animal protein.

In-vessel composting is done in drums, silos or concrete-like trenches. This type of composting is very similar to the bokashi food waste collection method as it is also done in closed containers in an anaerobic environment, except that waste is not treated with bokashi microorganisms and food waste is mixed with other organic material such as grass clippings and dry leaves in order to achieve the right carbon-to-nitrogen ratio (Iyengar & Bhave, 2006). In-vessel composting reduces odour generation and hence does not attract pests such as rodents and flies. It requires far less manual labour and much less land space than windrow composting. In a study done in India on composting household food waste using in-vessel composters, various different composter designs were tested, and it was found that one particular design, called the complete mix-type aerobic compost reactor (CM Reactor), was very well suited to household composting (Iyengar & Bhave, 2006). This design proved to be eco-friendly, efficient, cost-effective and nuisance free, thus making it an ideal solution for household waste separation and composting (Iyengar & Bhave, 2006). However, this study

only tested raw and cooked vegetable matter and therefore may only work well for cultures who do not consume much, or any animal fats and proteins. South African meals consist of a large portion of meat relative to other nations. Such composting methods for Enkanini could be tested in further research studies, to determine effectiveness and sustainability (this is mentioned in Chapter 5).

2.2.5.2 Anaerobic digestion

Anaerobic digestion is another method that has been used to process and biodegrade food waste, while simultaneously harnessing methane gas as an energy that can be used, for example, for cooking. A report by the Food and Agriculture Organisation (FAO) of the UN lists anaerobic digestion as environmentally preferable to both composting and landfilling (Food and Agriculture Organisation, 2013). The Official Information Portal on Anaerobic Digestion ([n.d.]) lists anaerobic digestion as the only out of four food waste processing approaches that is able to recover energy. This online portal states that anaerobic digestion can process all types of food waste, but not garden waste. It also states that this approach reduces GHG emissions and produces a saleable product.

However, anaerobic digesters require more infrastructure and would not have satisfied the objective of the overall research question, which is to determine alternative food waste treatment methods are imminently implementable in Enkanini. Heavy infrastructure takes much longer to implement, as was experienced first-hand with a research project in Enkanini by another ISUG researcher.[8]

2.2.5.3 Black soldier fly larvae

Another processing method is feeding the untreated, or bokashi-treated, food waste to black soldier fly larvae (BSFL) in a controlled environment. This is, for example, done at AgriProtein. The black soldier fly (BSF), or *Hermetia illucens (Linnaeus)* is a type of fly that lives between five and ten days and does not consume any nutrients while in the adult stage, as its primary function in this stage is to lay eggs to reproduce (Kotze, 2012). It is therefore not considered to be a pest and does not carry pathogens from source to food or other substrates, either. As larvae, the BSF feeds on decomposing organic matter, mould and algae (Texas A&M AgriLife Extension, [n.d.]). Once the larva has fed on enough nutrients and prepares to enter the next stage of its life by forming itself into a pupa, it crawls away from the food source. This characteristic makes the pupa easy to harvest. This pupa is extremely

[8] An anaerobic digester was implemented in Enkanini by Tavener-Smith in 2013.

high in protein and therefore a valuable source of animal feed that is more natural to most domestic animals than the more controversial fishmeal, and can therefore be used as a protein substitute. BSFL are able to process food waste at a much faster speed if compared to worms (Kotze, 2012). However, because they need oxygen to survive, the space needed to process food waste with BSFL is relatively large. If the food waste becomes too deep for the larvae, they could suffocate. Therefore, they need a shallow bed of food waste to thrive. The substrate that is left once the larvae have processed it is a soil-like material, dark in colour and neutral in smell. This substrate is not as high in nutrients as compost because the larvae have consumed most of the nutrients. However, it can still be used as a soil enhancer.

2.2.5.4 Bokashi

All the above-mentioned processing methods on their own would not have been ideal for Enkanini, given the constraints such as time, space, infrastructure and labour. However, separating food waste into buckets and treating it with bokashi neither completes the composting nor biodegradation process. The food waste is not biodegraded during the fermentation process because the carbon-to-nitrogen ratio is not correct (Van der Merwe, 2012). A common misperception about bokashi is that it is in itself a composting process, but it is simply a fermentation process that essentially pickles the food waste, as will be explained in Chapter 3. Once the fermentation process is complete after 14 to 21 days, bokashi food waste can be added to any of the above-mentioned composting processes, to an anaerobic digester, or given to BSFL to complete the full composting cycle. Alternatively, it can also be trenched, meaning it can be buried in the ground and left to decompose on its own, which requires no further labour. A criticism of bokashi is that it is an unnecessary component added to the above-mentioned food processing methods. Each method is capable of biodegrading food waste, although only certain kinds of food waste, in a safe and efficient manner if done correctly, in the right environment. Therefore, to add bokashi to the food waste would seem to many an unnecessary extra step.

However, the right environment, infrastructure and capital for the composting methods described above, as well as the anaerobic digester and the BSFL were not available. Bokashi though, seemed to fit the constraints of the project, because of the following advantages: It allowed participants to collect their food waste over a longer period of time without the food waste started to emit foul odours[9] and hence attracting pests. It was also very easy to use, and

[9] Foul odours are an indication of pathogens (Van der Merwe, 2012).

it did not require heavy infrastructure for participants or for us to process once it had been collected. Additionally, there was the convenience factor of not needing to separate food waste into further subcategories such as cooked waste, animal protein and acidic food waste, that are uncomplimentary to some other food processing methods, such as vermicomposting and anaerobic digestion. The microorganisms present in bokashi also prevent pathogens from breeding, which was a great positive for this project as the processing required a lot of hands-on work and it was also often a messy job. The bokashi allowed us to handle food waste without having to be concerned about pathogen risks.

Furthermore, bokashi-treated food waste will decompose faster than non-treated food waste if added to any composting process, and will also add beneficial microorganisms to the compost (Van der Merwe, 2012), thereby increasing soil quality as will be described in Chapter 3. When AgriProtein fed bokashi-treated food waste to their BSFL, they reported that the larvae seemed to process it at a much faster pace than untreated food waste, possibly because the fermentation process made the food softer and easier to digest (Kotze, 2012). Increasing the processing time of the BSFL could have positive revenue implications, but this study did not evaluate the possibilities any further due to time constraints. Moreover, bokashi-treated food waste can be added to anaerobic digesters as the microorganisms do not impede the gas production rate or the pH of the digesters, as a study conducted by students at the University of Cape Town shows (Chili & Norman, 2012) and the work of Pohl & Milan (2011 in Chili & Norman, 2012) confirms.

Essentially, bokashi increases the potential processing methods of food waste by prolonging the time it can be safely stored and handled (Van der Merwe, 2013). This suited the research project's requirements very well.

Part B

2.3 The South African Housing Policy on informal settlements

Services have in the past, under the previous public housing programme, the RDP, been viewed as part of a package that included the provision of a title deed, a house and all related services (Misselhorn, 2008 cited in Bolnick, 2009). It could be argued that this is still the overriding attitude governing policy implementation, even though the South African National Housing Code has officially shifted from providing a housing package to qualifying beneficiaries to the UISP under the BNG policy (Bolnick, 2009). This is a significant policy shift with considerable implications for informal settlements.

The RDP housing programme was an ambitious plan, which was implemented by the government in order to provide houses to all poor citizens who were able to prove that they earn below a certain monthly income (Bolnick, 2009; Del Mistro & Hensher, 2009). The construction of 2.9 million houses between 1994 and 2010 is certainly no small feat and it is one of the highest rates in the world of housing delivery to the poor. However, the government has failed to keep up with the increasing scale of need (Sexwale, 2009 cited in Bolnick, 2009). The urbanisation rate in South Africa is estimated at an average of 3%, while the annual population growth rate is 1.1%. Along with in-migration (a large-scale and continuing movement of populations moving into a region or community, specifically in this case moving into urban areas), this has resulted in a continuing proliferation of informal settlements in South African cities and towns (Bolnick, 2009). Along with the population growth and urbanisation rate came a shrinkage in household sizes, resulting in a housing deficit of 2.1 million units in 2009 (Housing Minister's Budget Speech, 2009 cited in Bolnick, 2009), up from a 1.3 million housing backlog in 1994 (Mafukidze & Hoosen, 2009). Once again, the real numbers are most likely far higher than the official numbers. This is due to various reasons, amongst others that families who do not meet the state's criteria for subsidised housing, but are still poor, are not taken into account.

Furthermore, the financially unsustainable RDP housing programme not only failed to keep up with the scale of need but also relocated informal settlement households to standardised dormitory developments located on the periphery of towns and cities (Huchzermeyer, 2003 cited in Del Mistro & Henscher, 2009). This placed families in inconvenient locations in terms of mobility, access to the city and job opportunities. Further, in the process of relocation, social and livelihood networks were weakened or destroyed.

Regardless of whether the RDP housing programme was successful or not, the fact is that the scale of need remains far greater than the rate of delivery (Bolnick, 2009). According to Misselhorn (2008), this leaves over five million South Africans without proper shelter and thus without proper services.

In 2001 the government adopted a policy that mandated the provision of free basic services to the poor. Since then, the emphasis has been on the provision of a basic amount of free water and electricity, according to the supposed amount that covers people's basic needs. With the incorporation of the UISP into the housing policy in 2004 the focus has shifted, theoretically, from providing a full housing package to incrementally upgrading informal settlements (Bolnick, 2009; Del Mistro & Hensher, 2009). Small but very significant changes have been

made to the policy since then, such as the emphasis on in situ upgrading. Also, the policy aims to minimise disruption by maintaining fragile community networks, and enhancing community participation (Del Mistro & Hensher, 2009).

Translated into broad terms, this policy shift theoretically enables service delivery approaches that are more flexible, integrative and participatory (Misselhorn, 2008 cited in Bolnick, 2009). Since 2007 the housing subsidy covers the top structure only as land and services were delinked from the housing subsidy, in line with a more incremental approach to housing provision. Land and services subsequently became the responsibility of municipalities. However, service provision as part of an incremental process is often more complex than assumed. As was posited above, service provision in a 'business-as-usual' manner may not always be financially, environmentally or socially sustainable. South Africa exhibits the desire to become more sustainable in all regards by, for example, signing on for the Millennium Development Goals, which pledge to ensuring environmental sustainability, as well as the Development Bank South Africa (DBSA) making a Green Fund available in order to 'green' its cities and economy (Green Fund, 2012). From this, it can be deduced that there is a mandate to redress service delivery as well. Therefore, when incrementally upgrading informal settlements and apropos service delivery, innovative and sustainable alternatives are sought.

2.3.1 Challenges in implementing the policy shift to incremental upgrading

The UISP, although more promising than the previous policy, has been lagging on implementation. As posited by Misselhorn (2008 cited in Bolnick, 2009), governments have been struggling to translate the BNG policy, specifically the UISP, into improved service delivery on the ground because it has not been accompanied by the necessary changes in mechanisms, systems and regulations. There is also a lack of concrete examples of successful incremental upgrading that local governments can look to for help. Political will to push for the take-up on alternative approaches has also been inadequate. Thus, the policy change has had little or no effect since its creation. Instead, UISP funding is often being utilised to fast-track subsidies for conventional development projects (Bolnick, 2009).

The challenge of translating the UISP into improved service delivery on the ground is not an isolated case. Lawhon and Murphy (2011) agree that most often conceptual frameworks for sustainable development "fail to translate theoretical ideas into effective strategies for human-environmental governance, leaving an uncomfortable gap between theory and

practice" (2011:2). Currently, conceptualisations of sustainable development gestate much about what constitutes sustainability and what the end product should look like but little about the social and political means for achieving a sustainable economy (Lawhon & Murphy, 2011).

In conclusion, municipalities are expected to incrementally upgrade service delivery in informal settlements in their districts but lack the know-how to do so. Little guidance and technical support are provided, other than stipulating very broad steps that need to be followed. The paradigm shift needed to start thinking in terms of alternative and innovative solutions has not occurred en masse yet. Tightly stretched municipal budgets seem to hinder this shift even further.

2.3.2 Incremental upgrading of waste management services

The World Bank has estimated that municipalities in developing countries spend 20–50% of their available budget on solid waste management (United Nations Environment Programme, 2009). Even though so much of the budget is spent on waste management, 30–60% of all urban solid wastes are not collected. Hence, less than 50% of the population is served in terms of refuse collections. The percentage of the MSW budget that is allocated to collections alone differs enormously between high-income countries and mid to low-income countries. A high-income country is estimated to allocate less than 10% of its solid waste management budget to collections, whereas a mid-income country spends 50-80% of their solid waste management budget on collections, and a low-income country spends up to 90% of this budget on collections (United Nations Environment Programme, 2009). This demonstrates the inefficiency of MSW collections in mid and low-income countries and points to the lack of community participation in efforts to reduce waste removal costs in these countries. High-income countries have the advantage of upfront community participation initiatives, such as recycling and recovery initiatives at the source of waste generation, which reduces collection costs. This frees up funds to fine-tune the waste management system.

Municipalities in South Africa are expected to adopt an integrated waste management plan which promotes the prevention, minimisation and recycling of waste (Engledow, 2005). They are also expected to incrementally upgrade informal settlements according to the UISP. The incremental upgrading process is divided into four phases, according to the National Housing Code (2004). In the first stage municipalities wishing to upgrade informal settlements in their districts have to go through the application process. If the application process is successful, the municipality is granted funding for the second stage, which includes activities such as

land acquisition if necessary, survey and registration of households, installation of interim services, and pre-planning studies. The third stage concerns itself with project implementation activities, such as establishing project management capacity and housing support centres, initiating the planning process, rehabilitating land where necessary, installing permanent municipal engineering infrastructure, and constructing social amenities and economic and community facilities. Finally, house construction commences in the fourth stage in what is called 'housing consolidation' (Republic of South Africa, 2009). .

As can be seen from the four stages of the incremental upgrading process as suggested by the UISP, the second and third phases are concerned with the provision of primary level services, which are aimed at addressing the basic health needs of a community. The definition of a basic service, as put forward by the Municipal Systems Act 32 of 2000 (Republic of South Africa, 2000), is "a municipal service that is necessary to ensure an acceptable and reasonable quality of life and, if not provided, would endanger public health or safety or the environment". As mentioned before, insufficient waste collection poses a risk to the environment and to human health (Medina, 2005). A lack of collection services leads to improper methods of waste disposal, which has a negative environmental impact and increases the risk of contracting and spreading infectious diseases (Murad & Siwar, 2008).

In January 2010, Cabinet adopted 12 outcomes within which to frame public service delivery priorities and targets. Each outcome lists several outputs in order to help Government achieve these outcomes. Outcome 8 deals with 'Sustainable human settlements and improved quality of household life" and the following targets are listed as related to improved access to basic services:

1. Water from 92% to 100%;
2. Sanitation from 69% to 100%;
3. Refuse removal from 64% to 75%; and
4. Electricity from 81% to 92%.

As can be seen from these figures, in 2010 36% of the South African population still had no access to refuse removal services. Refuse removal is also the lowest target of all service provision targets (75% for waste, compared to 100% for water and sanitation and 92% for electricity). Even though refuse removal is clearly stated here as a basic service, in municipal

practice ‘basic services’ most commonly only includes sanitation, water and electricity services (Dugard, 2013).

Butala, Van Rooyen and Patel (2010) define access to safe drinking water, adequate sanitation and solid waste management as basic services without which the risk of waterborne diseases increases. Given this, and the fact that refuse removal is in fact listed as a basic service according to the South African national government, it makes little sense why it is given so little attention on a practical municipal level.

As was mentioned above, South African cities and towns are struggling to roll out collection services to all citizens due to various reasons such as insufficient funds, inefficient collection systems and a lack of community participation. Therefore, municipalities should consider alternative methods of collecting solid waste by implementing innovative technologies. These technologies should be more cost effective and environmentally friendly than traditional methods and harness the active participation of communities.

Informal settlements are usually at the lower end of service level provision, not only because informal settlers cannot afford higher levels of services but also, more often than not, because the standard service delivery methods do not work for such settlements. Standard infrastructure and procedures are difficult to implement due to unsystematic layouts of shacks or problematic geographical locations, for example steep inclines. The fact that there is little or no conventional service level in informal settlements opens up opportunities to implement new and innovative alternatives without too much resistance from citizens to change.

2.3.3 Community participation during the upgrading process

Part three of the South African National Housing Code (Republic of South Africa, 2009) stipulates that the involvement of the community from the onset of a development project is key to ensure ownership of the entire process. This is because the community has a deep-seated knowledge of its development needs and preferences. Community members have invaluable knowledge to contribute to the design of the development project while experts often miss important contextual information (Smith, 2008).

In accordance with the National Housing Code and building on the BNG policy, the Western Cape Department of Local Government and Housing has developed the Isidima Strategy (Smith, 2008) that sets out how programs and projects should be delivered to contribute towards the creation of sustainable human settlements. The core focus of the strategy is influenced by three major shifts in policy (Republic of South Africa, 2007). The first is the

shift from pursuing housing construction to pursuing the development of sustainable human settlements. The second shift entails the emphasis on sustainable resource use and the third shift is the emphasis on real empowerment.

The shift in the Housing Policy to move towards empowering communities is a very important development and is one of the cornerstones of the Isidima Strategy (Smith, 2008). Objective 7 states that "a new pact is consolidated between Government and organised civil society to build up over time the trust, reciprocity and development practices required to imagine, design and implement vibrant sustainable neighbourhoods" (Republic of South Africa, 2007:12). Participatory planning is once again highlighted as an essential precondition in creating sustainable human settlements (Smith, 2008). The strategy states that the projects which have been most successful in terms of meeting the needs of the beneficiaries have been those where there was a high level of participation by the beneficiaries throughout all the phases of the project, including planning and design processes (Republic of South Africa, 2007).

Even though there has been a shift in policy to push for community participation and empowerment, the reality is that local politicians still choose to follow a paternalistic approach in their dealings with poor communities, by promising to provide for their supporters. Since the end of Apartheid the government has chosen to employ this paternalistic development approach, promising the delivery of services and houses to all its poor citizens (Huchzermeyer, 2006). Politicians receive support from communities depending on the extent to which they are able to broker such delivery. This approach has instilled a general attitude in citizens that it is up to Government to deliver on their promises while they, in the meantime, are helpless and powerless in their plight. As Huchzermeyer (2006) puts forward, this approach encourages individuals to sit back and wait for Government to deliver instead of acting proactively to improve their situation.

2.3.4 What does community participation mean?

In light of the previous section, it is necessary to flesh out the concept of community participation in the planning process, from which real empowerment supposedly stems. Community participation is often used as a blanket term solely to denote that an effort will be, or has been, made to involve the community in the development process. Without clearly defining what is meant by community participation, however, the good intention it symbolises in theory is easily reduced to tokenism in practice. Unfortunately, the lack of a

clear understanding of the definition and outline of this process of forming partnerships with a community in the past has tarnished the phrase and possibly even the concept.

The Isidima Strategy, as was already pointed out, proclaims that high levels of participation guarantee higher chances of success. Organisations, such as Shack/Slum Dwellers International (SDI) have therefore institutionalised the process of forming partnerships with communities so as to ensure representative and solid participation practices. The NUSP has also come on board by stating that "it is impossible to upgrade an informal settlement in situ without the complete and enthusiastic involvement of the residents" (National Upgrading Support Programme, 2013). They have consequently designed a resource kit for the executioners of their plan, which is aimed towards building partnerships with stakeholders (specifically part 3 of the resource kit).

The NUSP resource kit offers guidelines for putting in place 'institutional arrangements' so that the decision-making process is shared equitably amongst government representatives and community residents (National Upgrading Support Programme, 2013). On the NUSP's official website, a link to a document is offered that describes the correct process of setting up institutional arrangements. This document lists the importance of five aspects of development projects, namely management structures, criteria for participation, setting clearly defined roles for each participant, setting up frameworks which enable and optimise participation and the importance of the terms of reference which describe the essential details of the structure and which must be understood by all stakeholders.

Both the NUSP and SDI speak of concepts such as shared ownership, building understanding, trust and confidence, and essentially setting up leveraging tools for the poor to mobilise themselves in terms of upgrading their communities, which ultimately leads to their empowerment (NUSP, 2013; Slum/Shack Dwellers International, [n.d.]). The methods utilised by the two agents vary in that SDI, as a network of community-based organisations focuses on establishing women's savings groups in order to accumulate resources, whereas the NUSP, as a support device to municipal officials and state representatives, uses existing community structures such as ward and street committees to establish fairly rigid frameworks which supposedly enable community participation in a structured and democratic manner. The SDI method tends towards a grassroots approach to upgrading, whereas the NUSP follows more of a top-down approach in that the state initiates the project, appoints the project leader and lays out steps to be followed.

What both formulas have in common is a system or structure through which the developmental process is approached. To quote Slum/Shack Dwellers International ([n.d.]), "the discipline and systems required for strong savings groups are the base through which communities can manage and implement projects". Similarly, NUSP proposes "making institutional arrangements" in order to implement the process successfully. This adherence to structure and systems speaks to what Bowles and Gintis (2002) discuss in their paper "Social Capital and Community Governance" as a particular form of governance. Bowles and Gintis (2002) posit that the dominant governance structures influencing policy and institutional design today are based on the notion of competitive markets, well-defined property rights and efficient, well-intentioned states. Both SDI's and NUSP's formulas advocate strong (or good) rules of the game as the *sine qua non* of good governance.

Setting up institutional frameworks is important for taking a project to scale. However, there are two problems with the overall participation methodology as used by the government and many civil society organisations. The first is the methods that are described, which all rely on one fundamental condition, namely that not only are poor communities able and have the skills to participate, but they are also interested to participate in the planning process. The underlying attitude of many poor communities, which Huchzermeyer (2006) pointed out as one of righteous non-participation, is indicative of disinterest in the planning process. Also, even if there is interest and willingness from the community to participate in the planning process, the difference in power relations between stakeholders often prevents deep and meaningful participation. When participation methods are set up to reinforce power differences instead of levelling them out, participation quickly turns to tokenism instead.

The second problem is that the role that citizens, not only the state or institutions or structures, play in governance is not sufficiently addressed in participation methodology. Bowles and Gintis (2002) refer to this as "community governance" which they define as willingness to live by the norms of one's community and to punish those who do not, as well as a general sense of trust and concern for one's associates. Communities in this instance are defined as groups of people who are connected to each other through daily, multifaceted and frequent direct interactions. Community governance represents collective action in social problem solving and is built on relationships amongst people, namely how people interact in their daily lives, with their neighbours, families and work colleagues (Bowles & Gintis, 2002). Communities, markets and states are complements rather than substitutes, but with poorly designed institutions states and markets, will crowd out community governance. Therefore, it

is important to take into account collective efficacy of a community when designing institutions and not to underestimate the impact of personal interactions and relationships, which cannot be substituted by prescribed rigid frameworks.

2.3.5 Collective efficacy in South African informal settlements

Research has shown that factors such as a low rate of home ownership, economic disadvantage and general residential instability weigh heavily in favour of predicting low collective efficacy (Bowles & Gintis, 2002). All these factors are common attributes of informal settlements. This may be the case for many communities, but Huchzermeyer (2009) alludes to informal settlements as not only the manifestation of basic human needs but also as universal human needs, namely individual and cultural expression, access to a livelihood and to schooling, shelter and home-making and a sense of community. This indicates that there is potential for some sense of collective efficacy in informal settlements. Perhaps it is a sense of collective efficacy rippling under the surface but being repressed by the political economy, which reduces informal settlements to problems standing in the way of the golden path to development, and therefore they need to be "eradicated", "eliminated" and treated with "zero tolerance" (Huchzermeyer, 2009). These are all words used in Government's "language", or discourse, when speaking of informal settlements, and are also used by the United Nations (UN).

Governance structures in South Africa have effectively managed to exclude these human-needs-led settlements from participating in the formal processes of land subdivision and land-use control (Huchzermeyer, 2009). These informal land occupation processes driven by the poor have not only been undermined by the political economy and market-driven responses, but informal settlements have been stamped with a figurative 'yellow star', ear-marked for eradication. What this does to the human psyche and the ripple effects of that is probably, as yet, still largely unexplored. Nevertheless, Huchzermeyer (2001) proposes that South African informal settlements are unlike other slums in the world in that violence and gangs do not control them, and therefore they have the potential to make a positive contribution to urban development. This contribution is what civil society organisations, such as SDI, and implementation aids, such as the NUSP, are trying to harness. What the correct formula and supporting framework for true and meaningful participation is, is an extremely relevant question for informal settlement upgrading and this question will be explored further in this thesis, particularly through addressing the problem of inadequate waste removal services.

2.4 Conclusion

It is clear that urban waste management is a growing concern all over the world (Engledow, 2005). While some economically developed countries manage their waste effectively and are at the point of fine-tuning their waste management systems, they still remain with the problem of generating too much waste. Economically developing countries, on the other hand, do not generate as much waste as their developed counterparts, but their waste is poorly managed.

Waste management in South Africa, not unlike any other developing country, is facing an increasing population size, an accelerating urbanisation rate and a growing economy. This translates to increasing amounts of waste, industrial and household that will be generated. A backlog in waste services to urban and rural poor communities aggravates the situation even further and has led to illegal dumping, which damages environments and poses risks to human health.

The government has failed to keep up with the demand and need for shelter, ending up with an enormous backlog for housing and services. As a response to this, the South African housing policy has shifted from providing a top structure house with services and a title, to incrementally upgrading informal settlements in situ in a four-phase process. This has provoked much enthusiasm in terms of conceptualising the process of in situ incremental upgrading. However, few municipalities and even civil society organisations have managed to close the gap between the theory of in situ incremental upgrading and the practice thereof, resulting in little take-up on the ground and a continuation of the old housing programme.

Government and civil society organisations have identified community participation as a vital part of any successful development project. Meaningful community participation ensures ownership of the entire process, starting with design and planning, through to implementation, operations, maintenance. However, participation easily falls prey to tokenism if the participation framework of methodology and methods is not set up to allow for sincere relationship building and levelling of power differences between stakeholders. Deep and meaningful participation in the informal settlement upgrading process is an extremely relevant criterion, which will be explored further in this thesis.

Chapter 3 Methodology

3.1 Introduction

The format of the TD framework that was introduced in the first chapter will be carried over into this chapter. Hence it will be divided into the three phases of the research study. The principles and characteristics of TD that were covered in the first chapter influenced the methods that were chosen. These methods will be explained in more detail here, with the intent that, by the end of the chapter, a thorough understanding of the research process and methodology will have emerged.

The research process is described in a linear fashion by compartmentalizing actions and events into three distinct and successive phases, which could create the impression that there were clear starting and end points to each phase and that the process was executed with certain rigidity in terms of following a particular methodological action plan. This was, however, not the case. There was no methodological action plan, leading to a great deal of flexibility as to what methods were used, and the phases often overlapped, making it difficult to draw a distinct line between them. For example, actions that, strictly speaking, were part of identifying and contextualising the problem (Phase 1) coincided with actions that aimed to integrate knowledge (Phase 2), and sometimes one action served a dual purpose in that it helped to identify the problem and to integrate knowledge at the same time, for example the many field trips taken with the co-researchers.

It is therefore difficult to give a specific timeframe to each phase and to determine how many months were allocated to each. However, it is possible to give a timeframe for various milestones that were achieved during the study, keeping the milestones independent of what phase they belong to. One of the most important milestones was the establishment of an overall research question, which took about six months. The emergence of the research question was pre-empted by certain explorations and actions that will be detailed as part of Phase 1, although some of these would fall into Phase 2 as well, if viewed on a linear timeline (seeFigure3.1)

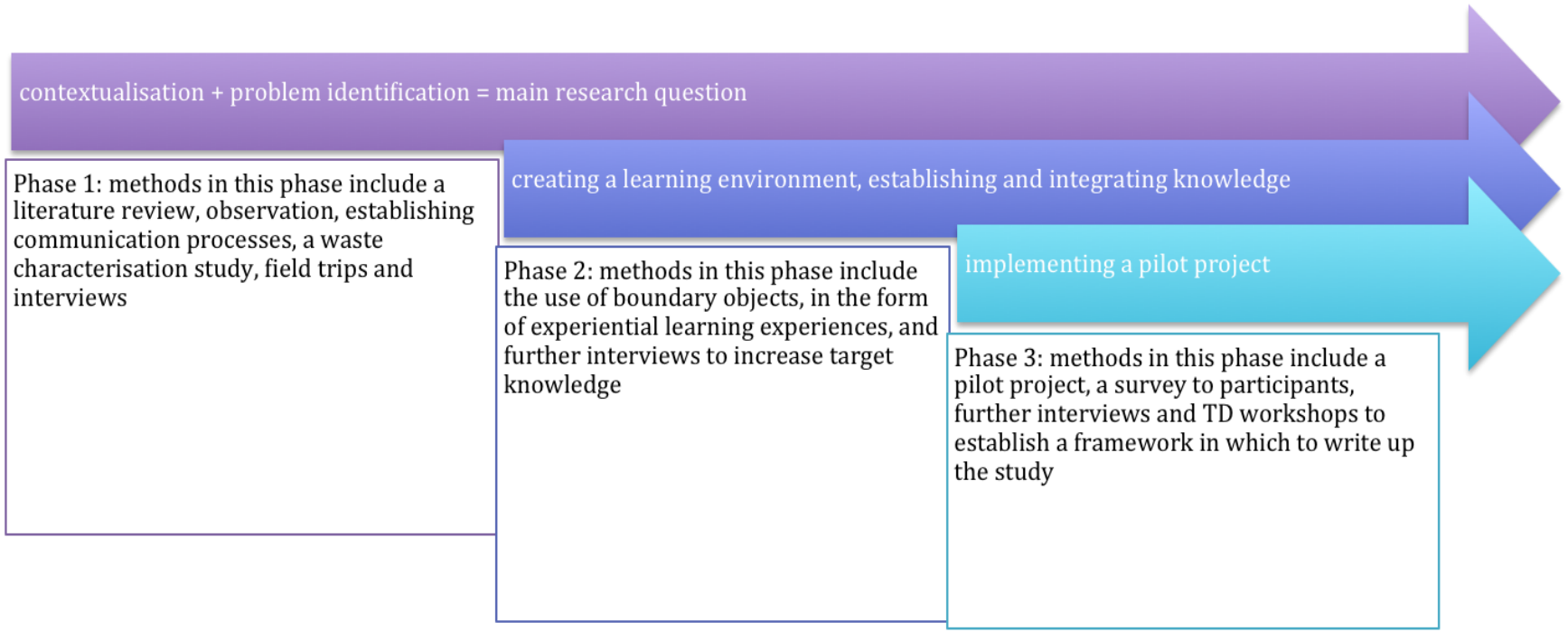


Figure 3.1 A linear representation of the research, detailing methods in each phase.

The diagram above is an attempt to portray the recursive TD research process as a linear process, even though it is more suited to a cycle, as portrayed in Figure 1.6 in Chapter 1. The methods that were used are listed below each phase. Rather than explaining each method in separate sections, the chapter is divided into the overarching phases and corresponding themes, namely contextualisation, problem identification, knowledge integration and pilot implementation.

Phase 1: Systems knowledge

3.2 Contextualisation and problem identification

Systems knowledge, as detailed in TD literature, concerns itself with "questions about the genesis and possible development of a problem field, and about interpretations of the problems in the life-world" (Pohl & Hirsch Hadorn, 2007:36). Systems knowledge forms the basis on which target and transformation knowledge can be built and is therefore necessary in a TD research process. Traditional research studies often concern themselves purely with systems knowledge and only rarely venture into the paradigm of target knowledge, and even more seldom into that of transformation knowledge (Pohl & Hirsch Hadorn, 2007). This means that academic knowledge is often not transformed from systems knowledge into target and transformation knowledge and hence is not practical for solving life-world problems. This, consequently, creates a gap between the academic realm and the life-world. In TD, and thus in this study, an effort is made to transform systems knowledge into target knowledge. Phase 1, consisting of contextualisation and problem identification actions, mainly concerns itself with systems knowledge.

In this study, Phase 1 could be divided into two parts. The first part of Phase 1 (Section 3.2.1) deals with actions that were part of the contextualisation process. The literature review that is covered in Chapter 2 was also part of the contextualisation process, but, due to its length, is detailed in a separate chapter. The literature review helped to contextualise the study within the academic arenas of waste management and informal settlement upgrading and thus forms part of populating systems knowledge in Phase 1. The second part (Section 3.2.2) explains the methods used to identify the problem. Furthermore, different forms of collaboration that can be used in a TD study are highlighted (Section 3.2.1.3), as well as which form of collaboration was most prominent during the implementation of the research methods. The form of collaboration is important as it sets the context in which all further methods were implemented. Following this, a short paragraph on reducing complexity, an important principle of TD, is given in Section 3.2.1.4. Reducing complexity took place at two distinct

points in time during Phase 1, of which one was a deliberate reduction of complexity, and the second instance a reduction of complexity that emerged organically through the engagement in various communication processes. Further reduction of complexity happened in the subsequent phases, but these will be highlighted in the relevant sections further down.

These contextualisation actions led to the formulation of preliminary research questions, which were used to help identify the problem. This is covered from Section 3.2.2 onwards. The problem identification process then leads to a reformulated primary research question, which signifies the end of Phase 1. For an overview of Phase 1, see Figure 3.2.

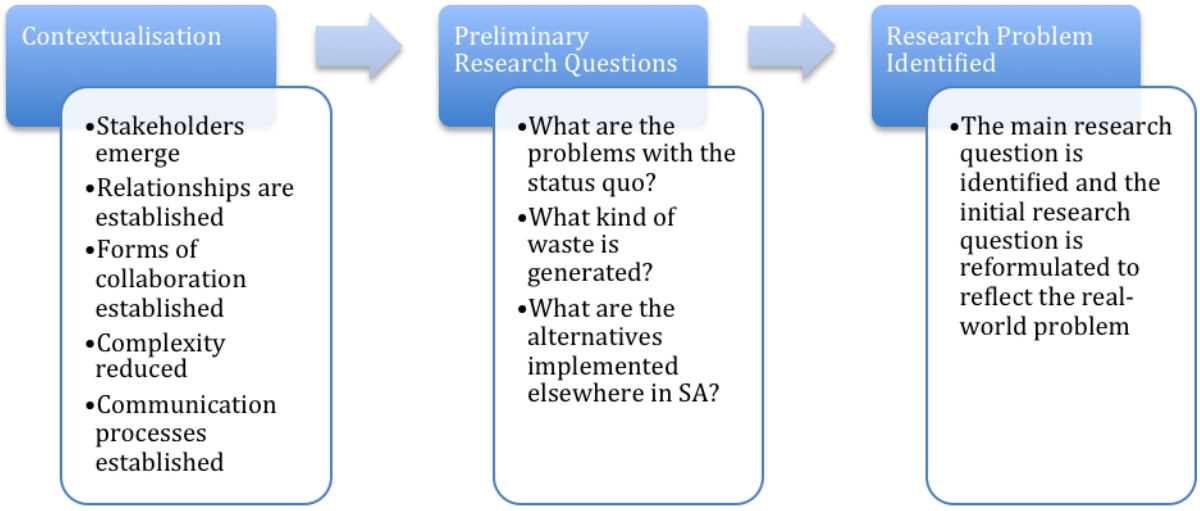


Figure 3.2 The process of Phase 1, starting with contextualisation and ending with a main research question.

At this point, it is necessary to mention reformulating the research question – an action that often occurs during a TD research process (this was briefly mentioned in Chapter 1). A TD researcher often begins the research journey with a pre-established research problem or question in mind. According to Jahn (2012), and Pohl and Hirsch Hadorn (2007) a pre-established idea or vision of the research process is present in the absence of a clear research question. As explained in the first chapter, these pre-established research questions, or ideas, are more often than not reformulated during Phase 1, as a result of the researcher embedding herself in the life-world context of the given study and engaging with life-world actors. Through this, the researcher is able to reformulate the research question in such a manner that

it addresses the most pressing need of the various life-world actors relevant to the study and thus speaks to what is perceived as the common good.

Jahn (2012) explains the reformulation process using the diagram depicted in Figure 3.3. Societal and scientific problems are combined and transformed to form a common research objective. The societal problem is taken as the starting point[10] and is transformed through the use of boundary objects.[11] Close ties are formed with scientific actors and a reflexive process is established so that the divergent expectations of the different participants can be managed, and feedback and reflection can be incorporated into the process.

Figure 3.3 The transformation process of the research problem in a TD study.
Source: Jahn (2012:3)

In this research study the pre-established idea presented in the proposal centred on researching behaviours and attitudes towards waste, which would lead ideally to a shared understanding of the problem amongst all stakeholders. It was imagined that from this shared understanding of the symptoms and causes of the unsustainable waste management system a more sustainable and appropriate waste management solution would emerge. However, at the time of proposing this approach to the study, it was not clear to me yet that the idea was situated within the systems knowledge paradigm without intent to move into the target and transformation knowledge paradigms. It is here where the gap between academic knowledge and the real-world problem would have been created, as this systems knowledge would not have had the capacity to transform current practices to new, desired ones and the life-world problem would most likely have continued to exist. As Jahn (2012:4) points out, researchers

[10] Taking the societal problem as the starting point, distinguishes TD from other forms of collaborative research (Jahn, 2012).

[11] Boundary objects are explained in Section 3.3.2.

cannot expect "that a solution to the identified scientific problem is necessarily a solution for the societal problem …".

However, by embedding the study in the life-world and going through the process of contextualisation and problem identification together with the actors in the life-world, the primary research question was reformulated according to the needs of the stakeholders. The needs were solutions oriented, and therefore the initial systems-knowledge focus needed to be adjusted to include target and transformation knowledge. Stakeholders were mostly interested in alternative waste management possibilities that could be implemented without much time-delay and thus relieve some of the immediate pressure the municipality was experiencing. They wanted to improve the living conditions of the Enkanini residents as soon as possible as they were already impatient with poor or inadequate municipal service delivery.

3.2.1 Contextualisation

This section will describe the contextualisation process, from identifying stakeholders to reducing complexity of the life-world problem. The five points that will be discussed are all actions of contextualisation that led to the establishment of preliminary questions, which in turn helped identify the main research question, which will be detailed in Section 3.2.2.

3.2.1.1 Emergence of stakeholders

At the commencement of the research study the stakeholders were not identified yet. There were, however, numerous actors in the life-world whom the study engaged and who were all relevant in the overall context of sustainable waste management, informal settlement upgrading and transdisciplinary research. The main research question was also not yet defined and therefore the research topic was still broad and encompassed various actors in the public, private and civilian sectors. As Phase 1 of the research process unfolded and the study was embedded more deeply within the life-world, certain actors slowly emerged as stakeholders. By employing the TD principle of open encounters (Pohl & Hirsch Hadorn, 2007), a solid network of actors within the academic and life-world was constructed. From these actors and the open encounters with them, the main stakeholders emerged, namely Haider, who represented the municipality; the co-researchers from Enkanini, Yondela Tyawa, Victor Mthelo and Sylvia Sileji, and Rupert Van der Merwe from Probiokashi (Pty) Ltd, a Stellenbosch-based private company that manufactures the substrate called bokashi that contains microorganisms for food waste processing. This group formed the core stakeholders, representing expert knowledge in municipal waste management systems and on bokashi food

waste treatment methods. They also had experiential and tacit knowledge of the everyday problems Enkanini residents face concerning waste management.

The following two tables (Tables 3.1 and 3.2) illustrate the various actors that were included in the network and what purpose they served.

Table 3.1 Academic/scientific actors of the broader network established for this TD study.

Actor	Sector/Role	Purpose
ISUG	Research group	Soundboard, brainstorming, guidance
Mark Swilling	Research supervisor	Guidance in general
John van Breda	TD scholar	Guidance in TD, soundboard
John de Wet	Facility Manager at the SU forestry department	Providing knowledge on bokashi
Michael Goldman	Professor at the Gordon Institute of Business Science	Providing knowledge on Tedcor
Alan Brent	Professor at SU's renewable energy department	Providing knowledge on life-cycle costing
Leanne Seeliger	Postdoctoral student in environmental ethics	Research and practical experience in Enkanini
Eve Annecke	Director of the Sustainability Institute and lecturer	Guidance on issues related to social dynamics and facilitation
Josephine Musango, Dr.	Senior lecturer at the TsamaHUB	Guidance in TD

Table 3.2 Life-world actors of the broader network established for this TD study.

Actor	Sector/Role	Purpose
Stellenbosch Municipality – Saliem Haider	Stellenbosch Municipality solid waste department	Expert on waste management
Tedcor employees and directors	Private sector	Evaluating alternatives
TrashBack – Andrew McNaught	Social enterprise	Evaluating alternatives
Let's Talk Rubbish - Cobus Smit	Consultant: food garden and solid waste management	Expert on gardening/composting with bokashi
Probiokashi (Pty) Ltd– Rupert van der Merwe	Private sector	Expert on bokashi microorganisms
AgriProtein – Cobus Kotze	Private sector	Expert on black soldier fly larvae (BSFL)
Organic Water Systems – Luke Davidson	Private sector	Expert on water and waste treatments using algae
Fred Rüst – private connection	Engineer	Providing advice on pilot design
Community Organisation Resource Centre (CORC) – Walter Fieuw	NGO	Information source on informal settlements
Love2Give2Children – Karen Ross	NGO	Expert on food nutrition through subsistence farming
Stellenbosch Municipality - Pietman Retief and Nokuthula Gugushe	Political party ward councillors	Support garnering
Enkanini resident – Msukisi	Enkanini resident	Advisor and consultant on Enkanini

Galada		through experiential knowledge
Yondela Tyawa, Victor Mthelo, Sylvia Sileji	Enkanini residents turned co-researchers	Advisors and consultants on Enkanini through experiential knowledge

3.2.1.2 Establishing relations in Enkanini

Given that Enkanini has no official leadership structure, and considering the strained relationship it has with the municipality, it was extremely difficult for the ISUG to enter the community and establish real, meaningful relationships. Enkanini residents are suspicious of outsiders, mainly because their frustration with the municipality has caused a general mistrust towards non-residents. This made it difficult for the researchers to be perceived as individuals who are not associated with the municipality and therefore did not have to be regarded with suspicion. Further, the usual point of entry for an NGO, a municipality or a researcher is the leaders of the community, but the weak leadership structure of loosely formed street committees and overarching ward councillors in Enkanini is corrupt and inefficient, hence making it inaccessible and risky for the researchers to try and establish a presence in the community through this avenue.

It was by chance, and with some luck on his side, that Andreas Keller (MPhil student in 2011) made contact during his research study with a man named Galada. Galada was affiliated with the street committees but unlike many of the committee members, he was held in high regard by a multitude of residents. Galada is well respected by residents because he is a priest; a ‘godly man’ who does not drink alcohol, dresses immaculately, is well spoken and has proven over time to have the best interest of Enkanini at heart and not let himself be corrupted by political or selfish interests (Wessels, 2012). Keller, by following his intuition that this man would be a good contact in the informal settlement, established a good relationship with Galada. This became the much needed entrance point into the settlement for the ISUG. Galada is well connected and was able to supply Keller with important information that only someone living in the settlement is privy to, hence allowing the research group to find further connections and quietly establish a presence in Enkanini that did not attract too much suspicion.

In the first half of 2012, the ISUG asked Galada to source at least three other community residents who had an interest in attending brainstorming sessions around incremental service

upgrading efforts in the settlement. It was through this process that we met Tyawa, Sileji, and Mthelo, whom Galada believed to be the right kind of people for what we had requested. They became the core group of co-researchers in the following months. However, it is important to note that it was never the ISUG's intention that these three residents would be representative of all Enkanini residents, and the ISUG is fully aware that three residents do not represent the opinions of all 4449 Enkanini residents.

The reasons for building a strong relationship with just three residents, instead of following the usual route of addressing the entire community through existing leadership structures and community meetings, were threefold. Firstly, these three actors provided the ISUG with an opportunity to step into the reality of life in Enkanini as experienced and perceived by its individual residents, similar to what Galada afforded Keller at the time of conducting his research. As covered in Chapter 1, a TD researcher needs to be able to transition into different levels and perceptions of reality (Andrén, 2010; Max-Neef, 2005), and this was made possible in this study through the close relationship I established with these three actors. Furthermore, because the leadership structures of Enkanini are unstable and corrupt, they are less accessible to outsiders to use as an entry point, and objectives are vulnerable to politicization. Lastly, Keller established the relationship with Galada in an organic way through embedding himself in the life-world context of Enkanini, and this organic process was a trajectory that subsequent researchers followed. Galada, whose advice the ISUG came to trust, implored that "quiet development" (Galada, 2012 cited in Keller & Wessels, 2012) was more desirable in the context of a tainted history regarding service delivery, and that the group should prioritize to remain under the radar where possible to avoid politicization and unnecessary attention (Keller & Wessels, 2012).

Tyawa, Sileji and Mthelo were introduced to the ISUG for the first time in Galada's shack in April 2012, a few months after the proposal of this study was accepted. At the time, the objective was to co-produce an institutional design for a larger solar panel project, which later turned into the iShack[12] project funded by the Bill & Melinda Gates Foundation, and thus the initial discussions revolved around this particular theme. Although these first

[12] The iShack project is a project that evolved from Keller's research in 2011 on energy poverty and ecological dwelling design. The outcomes of Keller's research were practically applied to a larger pilot project in Enkanini, which is currently funded by the Bill & Melinda Gates Foundation and the Green Fund (Development Bank South Africa). For more information on this project, see www.ishackproject.co.za.

brainstorming sessions did not directly relate to this research topic, it was beneficial that the group as a whole was establishing relationships with the residents that could then be taken forward by the individual researchers. This provided an immediate foothold into Enkanini, and personal relationships were formed with individuals that had no particular social, economic or political standing within the community. This reduced the complexity of possible social dynamics such as hidden political or personal agendas. Intuition, which in TD is an accepted role in the research process (Max-Neef, 2005), was the main motivator in pursuing a close relationship with these three individuals, rather than involving the larger community right from the start.

3.2.1.3 Forms of collaboration

This section discusses the four different forms of collaboration within a TD study that were identified by Pohl and Hirsch Hadorn (2007). The form of collaboration that was used for this study, namely 'integration by leader', forms the base of all subsequent actions that were undertaken herein. In transdisciplinary research, the researcher is not purely an observer that is distanced from the research subject and the relevant actors. Rather, the researcher takes on an active role within the group of actors that form part of the research study (Andrén, 2010).

The four different forms of collaboration between actors that outline different ways to organise group work in a TD study are the following: common group learning, modelling, negotiation amongst experts and integration by leader (see Figure 3.4). In each one the researcher takes on a different role, but all forms of collaboration have the same objective of identifying the problem and increasing shared understanding of it, to be able to collectively come up with solutions.

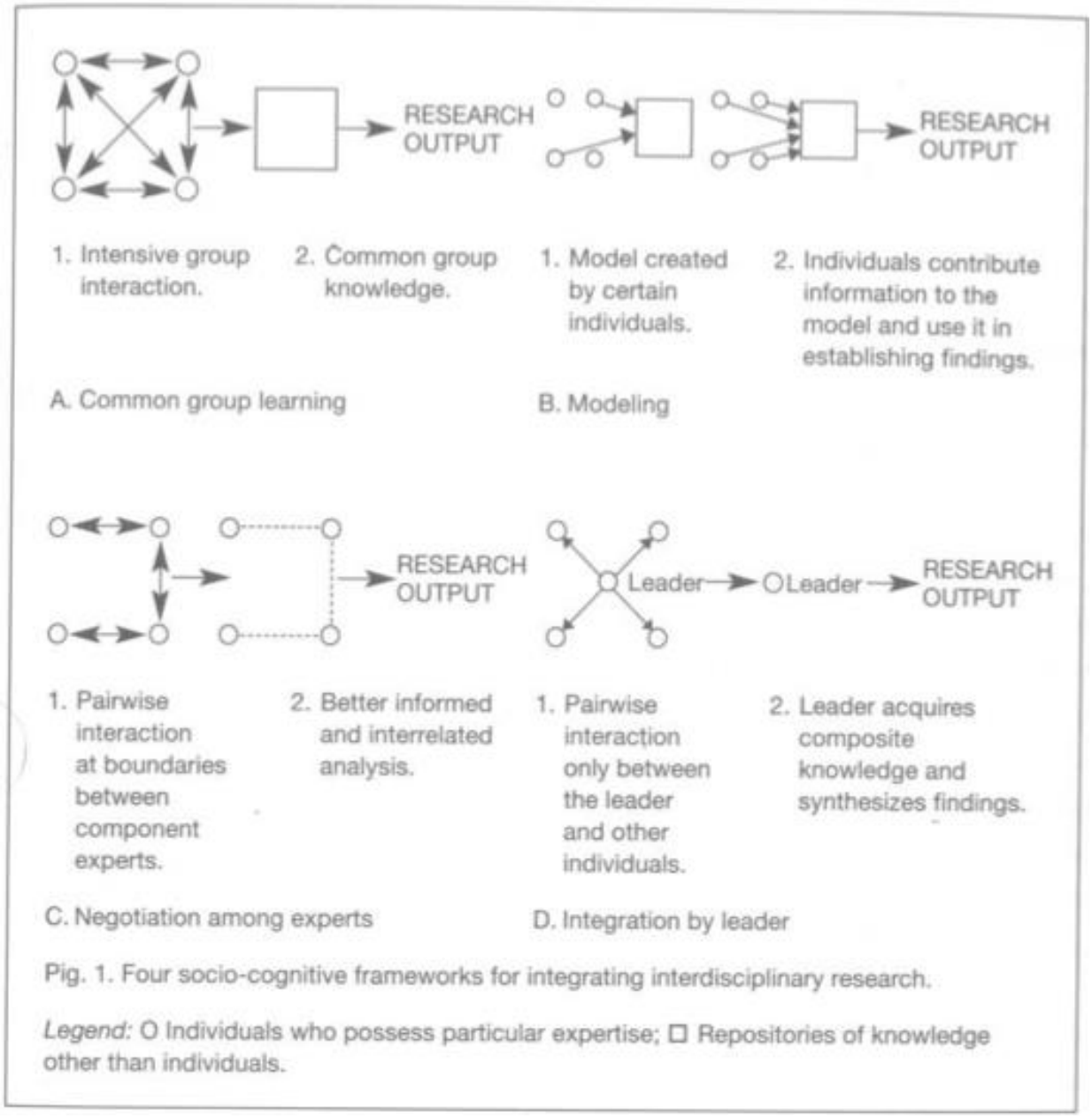


Figure 3.4 The four forms of collaboration in TD research.
Source: Rossini and Porter (1974:74) cited in Pohl and Hirsch Hadorn (2007:61)

1. Common group learning

In this form of collaboration intensive group interaction between all stakeholders leads to common group knowledge (Pohl & Hirsch Hadorn, 2007). All those involved in a TR project go through a common recursive learning and research exercise where sub-questions are initially distributed to appropriate group members according to their interest and field of expertise. Following this individual analysis, the group discusses results, which are then

related to the overall research question. This process is repeated and further rounds of analyses are carried out where the responsibility for the sub-questions changes hands to different members of the group regardless of their fields of expertise, until the group decides collectively on an adequate answer to the overall question. In this form of collaboration the group learns together through recurring group discussions.

2. Negotiation amongst experts

This form of collaboration for group work is similar to the common group-learning model, except that sub-questions are not analysed by multiple members of the group, regardless of their expertise. Sub-questions are rather assigned to group members according to their specific expert knowledge (Pohl & Hirsch Hadorn, 2007). The corresponding individual experts analyse the sub-questions and synthesise answers in a final stage of negotiation. In this model, the responsibility for the sub-questions and their answers remains with the corresponding expert, compared to the group-learning model where responsibility for sub-questions and answers lies with the group as a whole.

3. Modelling

The third form of collaboration is usually a quantitative model managed by some participants, while the remaining participants contribute knowledge and carry out assessments that are fed into the model (Pohl & Hirsch Hadorn, 2007). Modelling can also be a mode of integration (discussed in Section 2.3.2) as it can be used as a tool around which a common understanding can be developed and represented.

4. Integration by leader

In this form of collaboration immediate exchange amongst participants is not a requirement. A leader, for example the researcher, more often mediates exchanges and then integrates sub-results at the end. In this collaboration process, the leader selects the experts and determines what is expected of each actor or stakeholder. The leader also carries out the integration of various knowledge sets at the end. This form of collaboration was most similar to the collaboration process of this study in which I acted as mediator and facilitator between stakeholders.

There are no explicit advantages and disadvantages of each collaboration form. Rather, one form of collaboration may offer more benefits than another depending on the context of the study. For example, ‘common group learning’ is not appropriate in the context of this study, as not all actors are perceived to have equal power of knowledge. Unlike the global North,

where civil society is represented by strong institutional structures, the global South has no such support for actors who have no relevant expertise (Swilling, 2013) and whose experiential knowledge is not acknowledged.

3.2.1.4 Reducing complexity through collaboration

Reducing complexity is one of the preconditions of TD research, as it is necessary to arrive at a researchable problem. The collaboration mode 'integration by leader' seemed to be most appropriate in the context of this study, given that relations between the two main stakeholders, the municipality and Enkanini residents, are marred by prior tensions. Thus, indirect collaboration between them would reduce the complexity of this relationship. The co-researchers of Enkanini never met with Haider, the main representative stakeholder of the municipality, until after the pilot project had ended. The group of stakeholders also chose to not mention to the pilot participants that the pilot project was an initiative of the municipality as it was felt that this would compromise their participation rate.[13] Moreover, it would make the project vulnerable to politicization, which the stakeholder group wanted to avoid. In this way, the complexity of life-world relationships was reduced to a point where research could take place and a project could be implemented.

3.2.1.5 Communication processes

Various communication processes were embedded within the overall form of collaboration. I, as the researcher, took on a facilitator, mediator and connector role between these various communication processes. A TD researcher has to be willing and able to embed herself in many types of communication processes, not only in the academic arena, but also in the public discourse arena, the political arena and in various informal settings (Andrén, 2010). By placing myself into and between the communication processes, I was afforded 'glimpses' into different perceptions of reality from different viewpoints (See Figure 3.5).

One of these glimpses was obtained through the communication process with Enkanini residents, who are extremely frustrated with the municipality for delivering insufficient basic services and have, in the past, shown their frustration through aggression and violence towards the municipality as this is one of the only outlets to make clear their demands. Another glimpse was into the perceived reality of the municipality, which has a serious list of infrastructure backlogs to deal with, while facing an influx of more university students and

[13] It was never made explicitly clear to the pilot participants that the municipality was directly involved in the initiative. This decision was made collectively amongst stakeholders.

general Stellenbosch residents, and is seriously under-capacitated in terms of human and financial resources (SITT, 2012). Yet, these two realities have never met at any point and actors living in each of the realities can rarely understand the reality of the other, causing further frustrations and bad feelings toward each other (ISUG, 2012).

Figure 3.5 gives an overview of the four main communication processes that were taking place simultaneously and running parallel to one another. The continuous and extensive interactions within these processes pushed forward the project and opportunities emerged. In this way, at least two realities were able to converge, namely the reality of the municipality and that of Enkanini residents, even if just for a short period of time, without the usual feelings of aggression and frustration that have in the past accompanied interactions with the municipality.

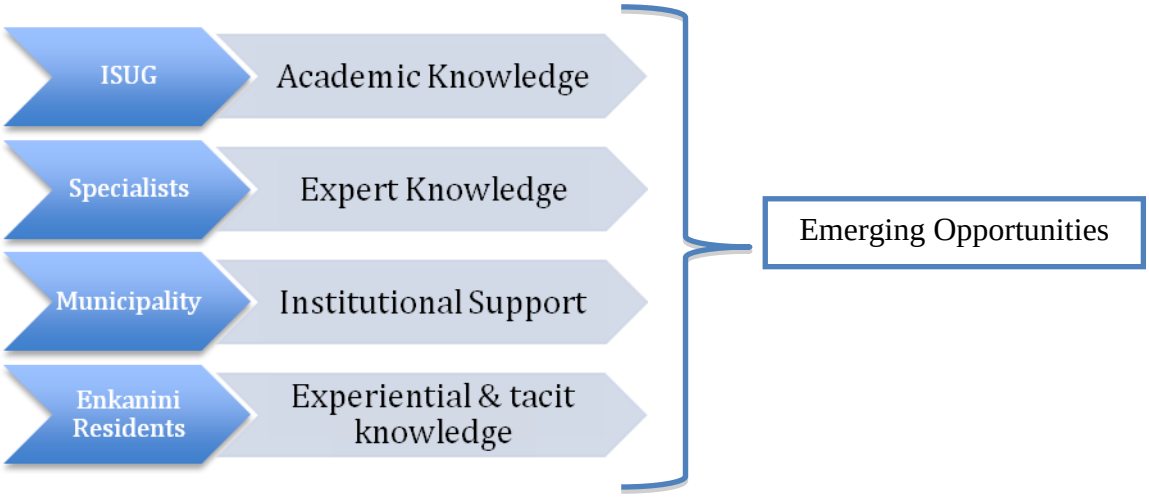


Figure 3.5 Communication processes within different types of knowledge.

Each communication process was important in tying together various points of view, similar to piecing together different parts of a puzzle. Communication with the ISUG was important as a soundboard, for brainstorming and as a reflection space. The communication process with specialists was mainly constructed by various field trips and interviews, which created a learning environment that spoke to experiential knowledge. The communication process that was established with the municipality was important in garnering their support to implement an intervention, and through their involvement the viability of the intervention for a governmental institution was able to be determined. The communication process established with Enkanini residents was vital in understanding the problem from their perspective, and tailoring the intervention with this in mind.

3.2.2 Problem identification

Through the above-mentioned contextualisation methods, which embedded the research study within the academic and life-world arena, the following research questions emerged as important questions in order to identify the problem. The three preliminary research questions that were established in order to achieve this, are as follows:

1. What are the problems with the current waste management system in Enkanini that are of social, environmental and economic concern, and what is the broader context, on a town level, within which it is embedded?
2. What kind of waste is being generated in Enkanini?
3. What are some of the alternative waste management (treatment) systems for low-income areas and informal settlements that are being implemented by municipalities, the private sector and civil society organisations in South Africa?

The following section will outline how the problem was identified, using the three preliminary questions as an outline.

3.2.2.1 Establishing the status quo and embedding it within the wider context

The research process started with a literature review at the beginning of 2012, which helped to ground the study in a broad, theoretical base. The weekly meetings with the ISUG that were taking place simultaneously to contextualise the study within the existing literature formed the initial bridge between the theoretical context and the practical application thereof. Through field visits to Enkanini that were used mainly to observe and meet people such as Galada, helped to begin contextualising the study further within the life-world and knowledge of the status quo was thus slowly being established. Walking around the settlement provided an overview of the state of the current waste management system, and by having informal, impromptu conversations with residents, some of the problems this waste management system was causing were determined.

One of the communication processes entailed regular meetings with the three co-researchers, specifically to discuss the topic of waste management within the settlement. Ten meetings, in which these conversations were held, spread out over a number of months and through this the three residents went from being actors to being co-researchers, as they embarked on a similar research journey to mine. These brainstorming sessions, as they were referred to from the early days, on various institutional designs for the iShack project, consisted of theoretical discussions around possible alternative waste management systems that were being

implemented elsewhere, such as the Tedcor model, bokashi, and recycling swop shops, all of which will be explained in the findings chapter in Section 4.2.3).

As this communication process continued, others started taking shape, such as a budding communication stream with Stellenbosch Municipality, initiated by attending regular meetings of the Stellenbosch Infrastructure Task Team (SITT) in a student and researcher capacity.[14] Councillors, high-ranking municipal officials, as well as private sector and university representatives attended these meetings. The objective of the SITT was to address the critical infrastructure backlogs that Stellenbosch Municipality was grappling with and to open up a much-needed dialogue on possible innovative, alternative solutions to the problem (SITT, 2012). Many connections were established through the SITT, such as connecting with the head engineer of Stellenbosch Municipality, Van Niekerk, and the chief town planner, Davidson, as well as other high-ranking officials. The SITT meetings were important in contextualising the research study in the broader setting of Stellenbosch, such as the pressing situation Stellenbosch Municipality faces with infrastructure backlogs and lack of financial and human capacity.

3.2.2.2 Waste streams generated in Enkanini

The second preliminary question that was established in order to identify the problem was what kind of waste Enkanini residents are generating, for example the percentage of plastics compared to metal, compared to food waste.

As mentioned in the introduction of Section 3.2 (Contextualisation and problem identification), the second instance of reducing complexity happened organically when an opportunity presented itself to categorise the waste generated in Enkanini. The first instance of reducing complexity was mentioned above, as the deliberate decision to minimize direct interactions between the stakeholders, who had a strained relationship historically. Haider, with whom extensive engagements had taken place within the municipal communication process, arranged a waste characterisation study of the greater Stellenbosch area in order to determine the waste streams of all the individual neighbourhoods that are included in the Stellenbosch district, including Kayamandi and Enkanini. Stellenbosch Municipality does not have the extensive data on its waste management system that it should (Haider, 2012), and to address the backlog issues the municipality needs to start collecting the necessary data and

14 My research supervisor invited me to these meetings.

statistics to understand the status quo in finer detail, which could consequently enable informed decision-making.

The municipality employed a number of Extended Public Works Programme (EPWP) workers to help with sifting through the black rubbish bags and separating the waste into the various waste streams. A number of interested students from SU were also arranged to help oversee and manage the separation process. Frances Bradfield, a Master's student in the Engineering Faculty was tasked with overseeing and managing the overall logistics of the characterisation study. Each area under jurisdiction of Stellenbosch Municipality was allocated two days from which to collect a representative sample of black bags. The sample size was determined by Bradfield and constituted 10% of each area. The bags were then sifted through and separated into seven different categories, namely hard plastics, soft plastics, tin and aluminium, glass, paper, organic/food waste, and other. The weight and volume for each category was recorded under the respective neighbourhood. The outcome of this study is given in Chapter 4.

The characterisation process for Enkanini helped to reduce complexity in that it revealed which waste streams were the largest and made up the bulk of waste generated in the settlement. Thus, it indicated which waste stream to focus on to make the biggest impact in terms of diverting waste from the landfill, and on improving the situation for Enkanini residents. Therefore, narrowing down the waste categories to focus on one particular category reduced the complexity of a very diverse waste stream, each with different characteristics in terms of size, bulk and problems caused.

3.2.2.3 Discovering alternative waste management models by creating a learning environment

The communication with the SITT opened up a further dialogue, namely one with a private company called Tedcor (Pty) Ltd. Two members of the SITT, Laubscher and van Niekerk, knew of a waste management model that was started a number of years ago in the Cape Town area, called the Billy Hattingh Scheme. Neither Laubscher, nor van Niekerk were aware of what had happened to the Billy Hattingh Scheme, but some desktop research showed that the Billy Hattingh Scheme had become a private company by the name of Tedcor (Pty) Ltd, operating successfully in multiple provinces of the country for over ten years. Contact was thus initiated with the Cape Town branch, specifically with their operations manager, Barnard, and explorations of this alternative waste management model for low-income areas began through this. The model is explained in detail in Chapter 4.

The communication process that involved Tedcor extended into in-depth explorations that also involved the three Enkanini co-researchers. The regular meetings between the co-researchers and me, which up until that point had involved purely theoretical discussions, started becoming more practical as we started going on various field trips together to experience the alternative systems in person, rather than only talking about them in theory. Moving from theoretical discussions to experiential learning trips was a conscious decision when co-researchers starting to lose interest in the discussion meetings. They also started expressing a certain boredom and impatience with the lack of practical implementations that they could relate to in experiential terms (Tyawa, 2012). The role of experiential knowledge, also referred to as tacit knowledge, is explored further in Chapter 4. (See Table 3.2 for an inclusive overview of field trips, which spanned both Phase 1 and 2 of the research process.)

The field trips offered a chance to create a learning environment through experiential learning opportunities and not only theoretical learning. Experiential learning was an important part of creating and integrating knowledge. As McFarlane (2011) states, learning is not only a cognitive process of acquiring knowledge in a linear way, but also an implicit experiential process of unconscious learning as we live our daily lives. Darby (2006) explains that explicit knowledge is that of facts, while implicit is more intuitive and gained through experience. Implicit knowledge often leads to explicit knowledge (Darby, 2006), as was the case with the co-researchers. They explicitly requested "less talking and more doing" (Tyawa, Mthelo & Sileji, 2012) and thus, creating experiential learning environments became a main theme of the research study and was a method used in many instances. For example, the pilot project itself was an experiential learning environment for its participants in which tacit knowledge was accumulated.

The explorations into Tedcor included smaller trips to view their Cape Town-based operations as well as a three-day trip to Johannesburg with two co-researchers to interview various ranks of Tedcor employees and to experience their waste management model on a larger operational basis. During the visit to Johannesburg, Tedcor's operations in various towns and areas were visited, including neighbourhoods in Rustenburg in the North West Province, and the Material Recovery Facility (MRF) where Tedcor has started a recycling initiative. Interviews included employees on various levels, ranging from the chairman to directors, managers and community employees such as truck drivers and garbage collectors (see Appendix C for a full list of interviewees). An interview with Michael Goldman, a professor at the Gordon Institute of Business Sciences, who had written a case study about

Tedcor for the United Nations Development Programme, Growing Inclusive Markets, provided a more objective perspective on the Tedcor model, as Goldman had never been employed by Tedcor and was simply interested in analysing their business model for learning purposes.

Further efforts to broaden experiential learning of alternatives included field trips to TrashBack, a social enterprise in Hout Bay that had set up a recycling system for the local informal settlement, a field trip to the Greyton Trash Festival, an initiative started by a Master's student to demonstrate the potential value of waste by upcycling it in various ways, a field trip to Probio's factory, a field trip to AgriProtein, a private company farming with various fly species that process various types of organic waste and smaller field trips in between such as a trip to Knorrhoek Wine Farm to view their vegetable garden and a trip to Legacy community centre in Kayamandi where bokashi kitchen waste is being used to make compost for the vegetable garden. Each field trip was followed by an in-depth discussion of the benefits and shortcomings of the various operations and a debate was initiated over whether similar operations would benefit the current waste management system of Enkanini. These field trips were conducted throughout Phase 1 and Phase 2, right up until the intervention was implemented in Phase 3. Even once the intervention method had been decided upon by stakeholder, field trips continued because, as explained above, these field trips were important in increasing tacit knowledge of sustainable waste management practices and the importance thereof, as well as helping to form closer relationships between the co-researchers and me.

3.2.3 Identification of overall research question

The problem identification procedure of answering the three preliminary questions was the process from which the overall research question emerged (as is depicted in Figure 3.2). The various communication processes within which these explorations took place led to a solutions-oriented research question that reads as follows:

What are some alternative food waste management systems that are imminently implementable in Enkanini and that will contribute to improving social, economic and environmental sustainability of the waste management system?

By embedding the primary research question in the target knowledge paradigm, the study moved beyond systems knowledge into the next (second) phase of the TD research process that deals with target knowledge.

3.3 Problem analysis and knowledge integration

This section will cover actions that were part of Phase 2, and how these differed from the ideal model of Phase 2 put forth in the literature. The main actions of Phase 2 are, traditionally, problem analysis and knowledge integration. However, due to the importance of increasing experiential knowledge as a knowledge integration tool, full knowledge integration was only possible through the intervention in Phase 3. The literature suggests that knowledge can be integrated through cognitive and linear learning processes (Pohl & Hirsch Hadorn, 2007), however, as will be explained in this section, experiential learning was necessary to achieve this. A differentiation is made between establishing target knowledge and integrating it, whereby establishing target knowledge rests in a theoretical paradigm of ideas and notions and integrating target knowledge brings about a paradigm shift to embed it in tacit and explicit knowledge. Knowledge integration methods, however, will still be discussed in this section, as these methods were already implemented in Phase 2 of this project, but only really took hold in Phase 3.

Problem analysis is described as the procedure in which the research question is divided into sub-questions, which, in turn, are dealt with and answered separately, and finally, answers to these sub-questions are integrated into a common knowledge set amongst all stakeholders in order to increase shared understanding of the problem (Pohl & Hirsch Hadorn, 2007). However, the action of problem analysis as outlined in the literature did not take place. This divergence from the theory was mainly caused by the life-world opportunity that emerged to implement a pilot project in Enkanini to test an alternative food waste processing method with the financial support of the municipality. The implementation of the pilot project was chosen as a tool to empower non-scientific actors to contribute more valuable knowledge and enable a more informed decision-making process regarding the problem statement.

Hence, Phase 2, as seen on a linear timeline, mainly consisted of beginning to implement knowledge integration methods through creating experiential learning environments, which continued into Phase 3.

The co-researchers had expressed interest in more practical learning, which they found easier to relate to (Tyawa & Sileji, 2012), rather than cognitive learning in theoretical contexts. The pilot project offered the perfect opportunity to create an experiential learning environment for a larger portion of Enkanini residents than just the three co-researchers. The usual route of

obtaining community input from a more representative sample, on whether bokashi would be an appropriate technology before going ahead with implementation, was not followed. This meant that the project could continue to 'fly under the radar' in terms of attracting unwanted attention from politically-motivated individuals. It could also be described as another effort to reduce complexity, because involving a larger resident consensus on the appropriate technology would have added unnecessary complexity to the process.

It was in this manner that the study moved from a systems knowledge to target knowledge paradigm. Target knowledge (as defined in Section 1.9) relates to not simply the cause of the problem, but the desired goal or change. It is therefore solutions-oriented rather than problem-oriented. The experiential learning environment created through field trips and by using bokashi to treat food waste had proven itself beneficial up to this point, in that it enabled a paradigm shift from systems to target knowledge for the co-researchers. It was a means of experiencing what possibilities were available and implementable, thereby increasing tacit knowledge. Increasing tacit knowledge is important, as Darby (2006) posits, because low levels of tacit knowledge make behavioural change extremely difficult and thus the chances of bringing about transformation knowledge are lowered.

In hope that the same would be applicable for a larger group of Enkanini residents, the pilot project was a tool through which tacit knowledge could be developed and a deeper understanding could gained of the problem itself, as well as how to acquire target knowledge through an understanding of possible alternatives to address the problem. Setting up the pilot project as a boundary object and using it as a means to acquire target knowledge meant that target knowledge would only be integrated fully amongst all actors at the conclusion of the pilot. Boundary objects (explained in the following section) were then used as a knowledge integration method. The co-researchers, Haider and I established target knowledge in Phase 2, whereas the desired goals for better practices for waste management in Enkanini were established through the actions of contextualisation. This is different from integrating target knowledge, as will be explained further in Chapter 4, but essentially integrating knowledge, in this study, refers to taking it from a theoretical idea into tacit and explicit knowledge.

Therefore, one of the objectives of the pilot project was to create a learning environment for stakeholders, such as the participants, the co-researchers and Haider. A learning environment is inherently a recursive environment, granted that learnings are internalised for the next phase of the project. This automatically satisfied one of the general principles of TD research, namely that of recursiveness, which points to the iterative procedures of both the entire

research process and the individual phases (Pohl & Hirsch Hadorn, 2007). In this way, the pilot project was used as a means to engage more stakeholders in a meaningful manner and incorporate their knowledge sets into finding a more sustainable waste management option.

3.3.1 Establishing target knowledge

As stated several times, transdisciplinary research tries to bridge the gap between academic knowledge production and knowledge requests for solving societal problems (Pohl & Hirsch Hadorn, 2007; Jahn, 2012). It is therefore a prerogative of TR to consistently defy the traditional "one-way knowledge transfer of allegedly reliable instrumental knowledge from experts to ignorant users" (Hoffmann-Riem *et al.*, 2008:4 in Hirsch Hadorn *et al.*, 2008). Instead, the researcher must give up the belief that she possesses superior knowledge that places her in a 'privileged' position compared to life-world actors (Andrén, 2010). An advantage for me in this regard was that I was neither an expert in waste management or in the broader theme of informal settlement upgrading, and therefore could not presume to have superior knowledge in either of these subjects.

My lack of expert knowledge, however, also made it necessary to connect with as many life-world actors as possible, in what TR calls open encounters, where different perspectives of the problem are taken into account and given equal importance. In this way, the various communication processes, which were covered in Phase 1, were established and knowledge was transferred between processes. For example knowledge of food waste management technologies was transferred to Enkanini residents, while knowledge of cultural aspects and attitudes in Enkanini, as well the problems with the current waste management system as experienced by Enkanini residents, were transferred to me, the municipality and Probiokashi (Pty) Ltd. Combining these knowledge sets, target knowledge of what is possible within this context was established.

One way in which knowledge was established was through the field trips with the co-researchers. The field trips, although described and categorised as part of Phase 1, also spanned Phase 2 as they continued taking place until shortly before the implementation phase (see Figure 3.1). Co-researchers were incorporated into as many field trips as possible, where direct knowledge transfer could take place between co-researchers and field experts, rather than acquiring this knowledge for myself first and then transferring it to the co-researchers. It was hoped that this would enable the co-researchers and me to feel on par in terms of 'superior knowledge', and the power balance was maintained at a more stable equilibrium. In this way, a balanced 'power-of-knowledge' environment was created, as alternative

possibilities for Enkanini were explored together and as bokashi microorganisms were explored in more depth.

3.3.2 Establishing and integrating knowledge through boundary objects

Pohl and Hirsch Hadorn (2007) and Jahn (2012) write of boundary objects as tools used to establish and integrate various knowledge sets. Boundary objects fall under the broader category of modes of integration, of which there are several. Any entity, whether it is an abstract idea, common everyday notion, illuminating example, artefact or publication, can be a boundary object if it is a common marker between different disciplines, actors and perceptions (Bergmann, Jahn, Knobloch, Krohn, Pohl & Schramm, 2012). It is therefore an object to which all involved actors with different perspectives refer without explicit communication between them (Pohl & Hirsch Hadorn, 2007). Therefore, boundary objects serve in reaching an understanding "across cognitive and normative boundaries" (Bergmann *et al.,* 2012:106). It is an interface through which all actors are able to communicate without making extensive efforts in translating and transforming concepts, theories and methods on behalf of the actors (Bergmann *et al.,* 2012). This mode of integration was therefore appropriate for the chosen collaboration form, integration by leader, which also does not require an immediate exchange amongst participants.

In this study there were several boundary objects that served to establish new knowledge and integrating knowledge (see Figure 3.6). Each boundary object led to the creation of another boundary object, as is illustrated in the diagram below (Figure 3.6). To reach a space of common understanding between the co-researchers and myself, a boundary object was needed to communicate about the importance of sustainable waste management and the options available to work towards achieving this. Therefore, one boundary object was the field trips that were undertaken together (see Table.3.3). The field trips were actions that increased tacit knowledge by increasing the understanding of various waste management options and to discuss with one another the possibilities for implementing such alternatives in Enkanini. Therefore, clearer communication was ensured without needing to deepen our understanding of one another's perspectives. For example, I never came to understand clearly why one of the co-researchers exhibited littering behaviour, even after he had discussed with me at length the problems that littering caused in Enkanini.

Here the boundary object replaced the initial research question, which focused on attaining an in-depth understanding of the perspective of Enkanini residents regarding waste-related issues, which would include an understanding of littering when waste services do exist.

Through the use of boundary objects it was not necessary to understand the others' perspectives in depth, as the boundary object enabled a focus on a more solutions-oriented study.

The second boundary object was the results of the waste characterisation study, determining the composition of the various waste streams. These results helped establish target knowledge amongst municipal officials, co-researchers and I, namely that it would make a substantial impact to remove food waste from the waste stream destined for landfill. Not only would the removal of food waste from the waste stream and a different processing method benefit the municipality, as it would save landfill space, but it would also impact the general living conditions in Enkanini. Currently, food waste contributes to many of the problems experienced in the settlement, such as festering waste that attracts pests, especially rats, which are a health hazard (Health and Safety Executive, [n.d.]). Food and any organic waste also produce methane and toxic leachate that can have detrimental environmental effects (Zero Waste New Zealand Trust, 2002).

The establishment of target knowledge through these two boundary objects contributed to establishing the main research question of the study, as presented in Section 3.2. The main research question could also be positioned as a boundary object as something that all stakeholders could refer to, but this was not made explicit during the study, hence it is included in Figure 3.6 below but indicated in green as only a potential boundary object that was never clearly defined.

The third boundary object created with the co-researchers was their use of bokashi, the technology that was to be used in the bigger pilot project. When Haider suggested a pilot project in Enkanini using bokashi, the first step was to take a field trip with the co-researchers to the bokashi factory in Devon Valley. After a factory tour by Van der Merwe, the proprietor of Probiokashi (Pty) Ltd, the co-researchers had the chance to ask Van der Merwe questions on the use of bokashi as well as the more intricate workings of microorganisms. After this tour a discussion session around food waste and the use of bokashi was held. The purpose of the discussion was to obtain feedback from the co-researchers on the use of bokashi and their thoughts on how it could be implemented on a wider scale. This cognitive, theoretical discussion was once again not ideal in helping to establish knowledge, as the co-researchers had no experiential knowledge of bokashi to refer to when discussing the possibility of a larger pilot project. Hence, it was organised with the municipality and Probiokashi (Pty) Ltd to purchase three bokashi kits (see Section 3.4.2 on a description of bokashi kits and how

they are used). Each co-researcher was given a kit to start separating and collecting food waste and treating it with bokashi. The co-researchers used bokashi for three months before the pilot project was implemented. This usage served as a boundary object in that it allowed for a common understanding of the practical functioning of the technology. The co-researchers gained experiential knowledge, thus establishing target knowledge, which in turn allowed them to give more valuable feedback and contribute to the design of the larger pilot project.

The fourth boundary object used in the study was the set of questions that was developed between Haider, the co-researchers, and me. Bergmann *et al.* (2012) refer to this as a "catalogue of questions" that can be used as a boundary object. These would be the questions that needed to be answered through implementing the pilot project and they established a common ground amongst stakeholders and me, which we could refer to. In Chapter 1 these are referred to as the set of sub-questions listed after the main research question (see Section 1.8).

Lastly, the pilot project itself, and the use of bokashi by pilot participants (discussed in Section 3.4), became a boundary object for all participants as they had an experience in common to refer to, similar to the use of bokashi by the co-researchers in the pre-implementation phase. Unlike the previous boundary objects that only helped in establishing target knowledge, this boundary object was the most successful in fully integrating target knowledge amongst all stakeholders. The way in which full integration was measured will be explained in Chapter 4. The pilot project also helped to establish transformation knowledge in that it indicated the beginning of a change process. All of this is explained in Chapter 4.

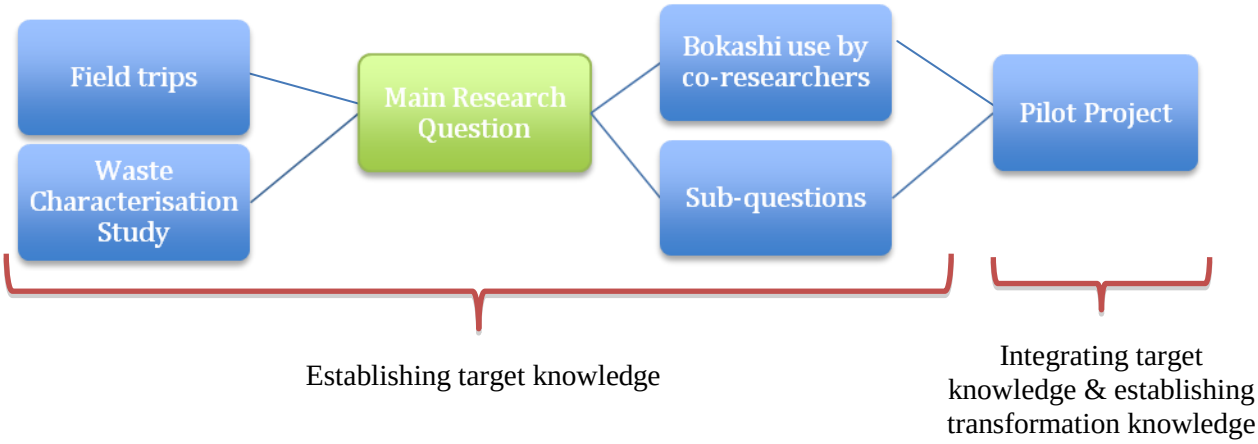


Figure 3.6 Boundary objects that established and integrated target knowledge.

Phase 3: Transformation Knowledge

3.4 Bringing results to fruition

So far the contextualisation and problem identification process that took place in Phase 1 has been covered, where food waste was identified as one of the most pressing life-world problems in Enkanini. In Phase 2 it was explained how target knowledge was established, mainly through the use of boundary objects, which all led to the implementation of the pilot project (also described as a boundary object) and achieved the integration of target knowledge and establishment of transformation knowledge. For the narrative of the research process to make sense, it is necessary to first explain where the physical base of the research in Enkanini unfolded from, which was the same space that became the bokashi hub from where the pilot was operated from (Section 3.4.1). In Section 3.4.2 more detail is given on how bokashi technology works, before the actions of Phase 3 are detailed from Section 3.4.3 onwards.

With the catalogue of sub-questions, established in Phase 2, in mind, Phase 3 commenced with multiple discussions with various stakeholders to design and implement the pilot project. Three meetings were held with the co-researchers to plan and discuss the implementation of the pilot project. These were spaced irregularly, according to when decisions had to be made. In one of these meetings Cobus Kotze, an employee and the point of contact at AgriProtein,

joined the discussion. Kotze had been acquainted during the field trip to AgriProtein. He was interested in the project and how it would be implemented, as AgriProtein is interested in using their technology of black soldier fly larvae (BSFL) in informal settlements to solve waste management problems (Kotze, 2012). BSFL will be explained in detail in Chapter 4. Kotze has some experience with waste projects in low-income areas and had some valuable input for the set-up of the pilot, especially in terms of incentives, which will be covered later in this section. Informal discussions were held with Lauren Tavener-Smith, a fellow ISUG researcher, for further design brainstorming related specifically to data collection accuracy.

A meeting was also held with Fred Rüst, an engineer by profession and a personal family friend, who was questioned about very specific aspects of the design of the study, such as a trolley design for waste collections within Enkanini. Andrew McNaught, one of the founding members of TrashBack (discussed in detail in Chapter 4), gave further input on the design. And lastly, Professor Brent from the Centre for Sustainable and Renewable Energy at SU was approached for a possible life-costing model for the project. However, this project never took place due to time constraints.

3.4.1 Acquiring a space in Enkanini from which to conduct research operations

In June 2012 an opportunity emerged for the ISUG to purchase[15] a shack in Enkanini, which could then be used as a base from which to conduct research activities within the settlement. Galada told the ISUG that a shack in section E, which had been used as a church, had become vacant as the owner had moved back to the Eastern Cape and was now trying to sell the shack. 'The Church', as the shack was initially called, is a relatively big property given the average size of a shack in Enkanini. The ISUG had been considering renting a shack in Enkanini, as the group often required a space where we could conduct meetings and also to sleep over, when required for research purposes. With the consent of our supervisor, Swilling, the ISUG purchased 'The Church', which would later become known as the Enkanini Research Centre (ERC). This also meant the group had a space where we could conduct experiments in our

[15] There is an informal property market in Enkanini, where shacks are sold and rented out even though the land they are situated on does not belong to the residents. Initial rights to a property are on a 'first come, first serve' basis, according to who first erects a shack on a free section of land (Galada, 2012). Property boundaries are determined on the same basis.

own, individual, research fields, if the need arose. The picture below (Figure 3.7) indicates the location of the ERC in Enkanini.

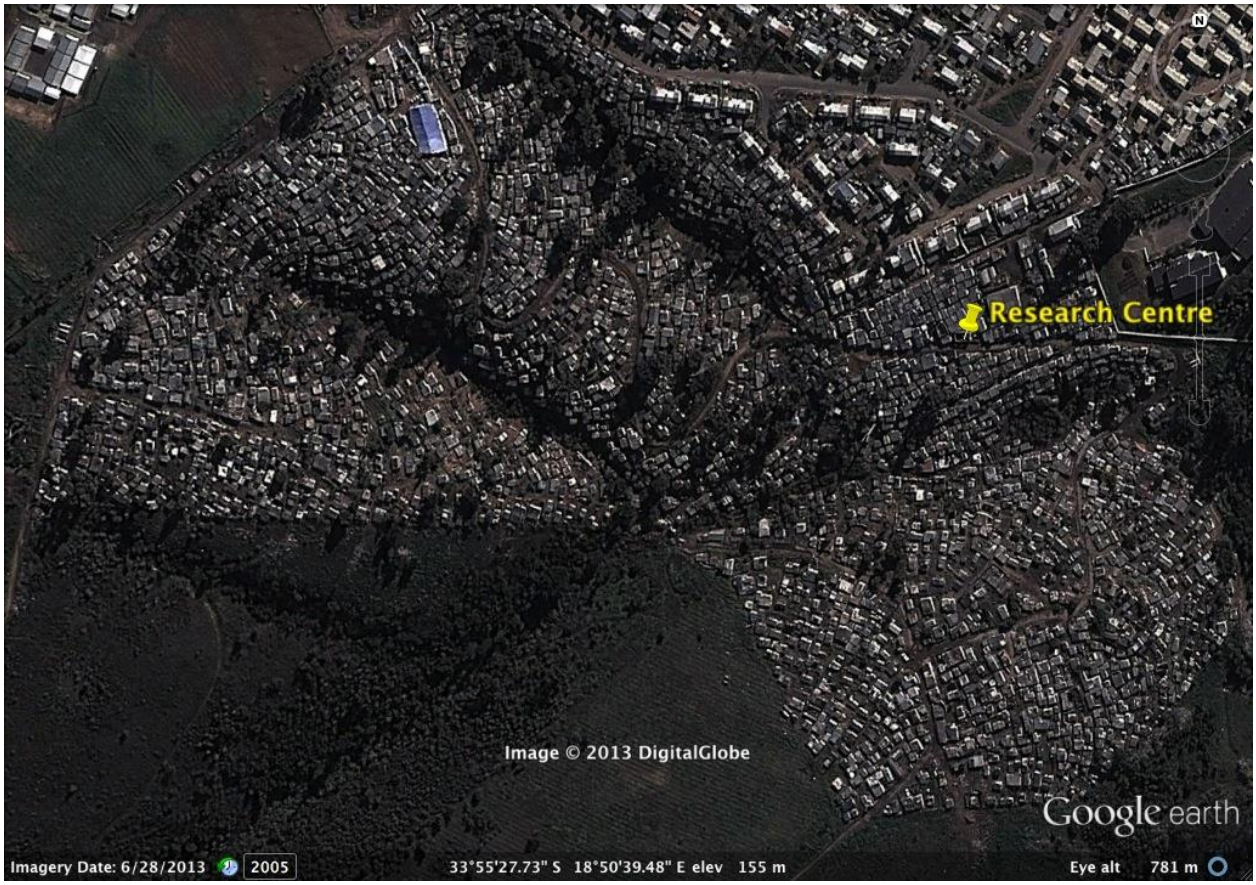


Figure 3.7 Location of the research centre in Enkanini.

Source: Google Earth. 2013. [Online] Available: http://www.google.com/earth/. GPS co-ordinates: 33°55'28.18"S, 18°50'41.57"E. [20/10/2013]

3.4.2 A description of bokashi

This section will briefly explain what bokashi is and how it works. Bokashi is a carbon-based substrate, such as sawdust or bran, inoculated with effective microorganisms (EM) that aids in the decomposition of organic matter through a fermentation process (Barnes & Burt, 2009). Dr Higa of Ryukyu University in Okinawa, Japan originally developed EM in 1982, and which is composed of several microbial groups of bacteria that live interactively and synergistically with each other (Koh, Song & Kim, [n.d.]). Essentially, the process of bokashi, or any other EM product when used to treat food waste, can be described as a treatment method that changes the characteristics of the food waste in such a way that the options of eventual processing methods are widened (Van der Merwe, 2013). For example, food waste

that has been treated with bokashi can be used in vermicomposting, anaerobic digesters, BSFL processing and other more traditional composting methods.

The EM comprises various groups of organisms, generally consisting of the following four overarching groups (Barnes & Burt, 2009):

1. Lactic acid bacteria *(Lactobacillus sp., Streptococcus sp.)*
2. Photosynthetic bacteria *(Rhodopseudomonas sp., Rhodobacter sp.)*
3. Yeasts *(Saccharomyces sp., Candida sp.)*
4. Actinobacteria *(Micrococcus sp., Arthrobacter sp., Nocardia sp., Streptomyces sp.)*

These four groups of bacteria each have properties that, when grouped together, thrive in a fermentation process (Barnes & Burt, 2009). Antibiotic properties and other properties such as anaerobic decomposition of substrates also enable them to act as a probiotic, which has a number of uses besides that of fermenting food waste. These uses include disinfectant properties, odour-suppressing properties, wastewater treatment capabilities and probiotic use for human as well as animal digestion, amongst others. Odour suppression occurs through the putrefaction prevention of the food waste, which simultaneously means that pathogen breeding is hindered. The lactic acid bacteria play an important role in odour suppression as the production of lactic acid dramatically reduces the pH in the early stages of the fermentation process (Koh, Song & Kim, [n.d.]). An offensive odour indicates the presence of toxin-producing pathogens (Probiokashi (Pty) Ltd, [n.d.]). However, EM products are able to directly and indirectly suppress pathogenic microbes, such as salmonella or the pathogenic strain of E. coli, thanks to their aforementioned properties. To summarize, the function of EM in the bokashi process is to facilitate the enhanced degradation of organic waste, first in an in-vessel system and subsequently in the natural environment (Barnes & Burt, 2009).

An advantage of the bokashi system is that it can ferment any type of food waste, whether this is animal fats and proteins such as meat and fish, cooked or uncooked food waste or the more acidic food such as onions and citrus fruits (Van der Merwe, 2012). This is convenient for the user because no further separation is required, and it is advantageous for the environment because all food waste can be processed with one treatment method, making sure that problematic wastes, such as meat and bones, are not still thrown into the concrete bays, where they breed pathogens or attract pests. The fermentation process also enables food waste to be stored indefinitely (Van der Merwe, 2013). This property, along with the pH

neutralising effect, means that bokashi-treated food waste can be safely handled and processed in many alternative ways over and above the traditional methods of processing food waste. This is opposed to the non-treated food waste that cannot be processed in other than the traditional ways because the food waste poses health and safety risks. This is what 'increasing the final processing options of food waste' means. Other composting or food waste processing methods (discussed in Chapter 4) are more sensitive in terms of what food waste they are able to process.

3.4.3 Pilot project design

The first step in the design of the pilot project was to obtain the bokashi kits that were provided by Probiokashi (Pty) Ltd. One kit consisted of two 25 litre buckets stacked, the inner bucket with a porous bottom to allow for liquid drainage, which the outer bucket captures, and a lid to keep the process anaerobic. In order to cut down costs as much as possible, Haider and Probiokashi (Pty) Ltd decided on this simpler bucket system rather than the more expensive bokashi buckets imported from Thailand. Buckets imported from Thailand have a tap fixed to the bottom specifically for the purpose of liquid drainage, but it makes the buckets more than four times more expensive (Van der Merwe, 2012). Probiokashi (Pty) Ltd sourced the buckets from one of their plastic suppliers and the municipality bought them at cost at R25 per bucket. Two buckets were necessary as there was no other cost-effective way of draining and capturing the liquid. Not draining the liquid from the food waste would be detrimental to the microorganisms, as they could eventually drown, and the buckets would also become very heavy. As will be explained later, participants were required to carry the buckets, so from a convenience perspective, we wanted to keep the buckets as light as possible. The bokashi substrate was supplied by Probiokashi (Pty) Ltd in one-kilogram bags, and participants received a new bag each time the previous one had run out.

These aspects of the pilot design were decided upon unilaterally by the stakeholders that had greater decision-making power in terms of financing the project and supplying the technology. The decision to use bokashi for the pilot project, the agreement on prices and the set-up of the kit were exclusively decided by Haider, who had control over the funds, and Van der Merwe, as the supplier of the technology. After the price had been finalised, Haider contacted me to ask whether I would like to manage the implementation of the pilot.

Haider was initially very eager to start off with a larger number of participants. Initially he wanted to include 500 participants. After discussing this, it was decided that the capacity for such a large number of participants was lacking due to insufficient storage space for all the

food waste collected from 500 participants, and insufficient human capacity to organise and manage the logistics for such a large project. The decision was made that it may be better to start off smaller to see what the participation and adoption rate would be like, and to get a clearer idea of space and infrastructure requirements. If feedback and participation were positive, the project could go into a second phase, with more participants. It was agreed that 100 participants would be a more manageable sample.

The meetings with the co-researchers were directed at finding the most appropriate manner in which to set up the pilot in Enkanini. The questions that were addressed and discussed in these meetings were the following:

1. Should participants drop their food waste at a certain location or should food waste be collected?
2. If the food waste were to be collected, should it be collected from the individual shacks or should there be several collection points that group together several participants, thus making the distance to the collection point a little bit closer?
3. What are the logistics of doing collections, both from individual households and from various collection points?
4. What selection process should we implement to determine participants?
5. How should selected participants be contacted to invite them to the information sessions?
6. What are the ‘rules of the game’:
    a. What should be done if a bucket has been lost or gone missing?
    b. What days should collections and/or drop-offs take place?
    c. How should the food waste be processed further and where should this be done?
7. Should there be an incentive for participants, and if yes, what should we offer and how?

The co-researchers, having gained experiential knowledge in using bokashi, as well as having tacit knowledge of their environment and the culture of Enkanini, were in a position to give valuable input in discussing the aforementioned questions and on what they thought would work on a larger scale. Therefore, the decisions on the project design were largely made during these discussions, in combination with the input we received from Kotze, Tavener-Smith, McNaught and Rüst. The questions were divided into four different subgroups and tackled during different discussion rounds (see Figure 3.8), the first dealing with the question

of collection versus drop-off, the second with participant selection criteria, the third with the 'rules of the game', and the fourth with the question of incentives for participants. The questions had been divided in this manner to achieve an easier overview of the details of the pilot design. The actual process was less structured. The decisions of each question are explained in more detail below.

Figure 3.8 Four discussion rounds to discuss the seven questions of the pilot design.

At the conclusion of the pilot project, a survey was administered to as many of the participant households as possible to gain feedback. The surveys were administered on the last drop-off day of the project, and also at the last barbecue event where a table was set-up and an announcement was made that anybody who had not filled out a survey and would like to give feedback could come to this table to do so. On both occasions the co-researchers administered the survey as they could translate the questions in Xhosa and also write down the answers in English if the respondent couldn't speak or write in English. The co-researchers were taken through each question beforehand to make sure they understood what it was that was being asked. 90 surveys were administered.

3.4.3.1 Discussion Round 1

The questions dealt with in the first discussion round are structured around the issue of collection versus drop-off of food waste. The questions are questions 1–3 listed in the previous section (see Figure 3.8).

The co-researchers first recommended that food waste should be collected from individual households or at least to have various collection points within the settlement from which to collect. This was proposed to ensure that participants would not have to walk too far with their food buckets. In their experience, they had found the buckets to become very heavy when filled with food waste and a concern they had was that the weight of the buckets may deter participants from walking to the ERC to drop their waste there, hence affecting motivation to participate. The ERC was located in Section E, as seen in Figure 3.7, and the intention was to have a representative sample of participants from all sections, meaning that some would be located further away from the ERC than others.

Numerous conversations with actors before the implementation of the pilot project revealed a great deal of doubt in whether people would actually participate in separating their food waste from other waste (Haider, 2012; Brent, 2012; Petersen, 2012; Rüst, 2012). Brent (2012) expressed doubts about whether people would remain diligent enough to separate food waste from other waste, and Haider (2012) had similar doubts. Expectations were that buckets would be used for other purposes, or that a lot of non-food waste would be found in the buckets. Co-researchers had expectations that many of the buckets would disappear, as there was a big demand in the settlement for buckets that can be used for carrying water, washing clothes, storing food and as a toilet. This gave rise to my own doubts whether people would actually use their buckets for the intended purpose and whether other non-food waste would be thrown into the buckets. From personal experience in starting a recycling process at home, I realized that this behaviour change is not easy to adapt to when one is used to the convenience of throwing everything into the same rubbish bag. Reis and Vincente (2008) concurs, as will be discussed in Chapter 4. Therefore, in order to increase motivation to participate in the pilot, the process had to be as convenient as possible for residents, in hope that the more convenient the process was, the higher the chances of adoption. Adoption rate includes correct waste separation and buckets being used for their intended purpose.

Although the co-researchers' concerns of the weight of buckets possibly affecting people's motivation to participate in the project was taken into account, and that collections from individual shacks would be the most convenient option from the participants' view, the

capacity to perform collections was extremely limited. Collections, either on an individual level or on a multiple collection-point level, would be impossible. The concern over these limitations was discussed with the co-researchers, which led to the idea to split the sample of participants into two groups; one that would have to walk to the ERC to drop their food waste there and one that would have their food waste collected from their shacks, thus reducing the number of participants from which to collect.

After further discussions, including a discussion with Rüst, the engineer, about a trolley design that would allow collection of drums and buckets with more ease, and envisioning how this process would work, it was decided that even this would stretch the capacity over the limits. The co-researchers also expressed concern with this option, as it could instigate tension between the two groups when the participants of one group would realize that the other group had their waste collected from their shacks. This would also affect motivation and discourage participants to drop off their food waste. The co-researchers communicated that in their experience jealousy between residents quickly erupts if there is a perception that one group or individual is receiving preferential treatment in any way.

It may have been interesting to compare these two groups in terms of their motivation to participate in collecting their food waste, but contributing to a sense of jealousy amongst participants would have been detrimental to the reputation of the project. Avoiding politicization was important to reduce the complexity of the life-world problem.

Dividing participants into two groups would have also added complexity. Recalling the overall research question, the objectives were to find out which food waste management systems were imminently implementable in Enkanini in a socially, environmentally and economically sustainable way, with the sub-question of how participants would respond to the technology. Because the project was designed to be recursive, the way in which the technology will be implemented eventually would enable participants to give feedback. The learnings from this would then be implemented in the next instance of bringing results to fruition, given that financial and human capacity would be sufficient to allow for changes.

Through this process it was concluded that (1) there would be no differentiation between the participants into groups of ‘collections’ and ‘drop-offs’ in order to try avoid as many demotivating factors as possible, as well as to reduce complexity, and (2) that all participants would be required to drop off their food waste at the ERC because the capacity to carry out collections of any form was simply not there. This meant that all participants would have to

carry their bokashi buckets to the ERC, but that some would have a further distance to walk than others, and that some may have to walk uphill whereas others may be walking downhill. Motivation amongst participants would then be observed and feedback on this particular aspect of the pilot design would be obtained. By then, all participants would have experiential knowledge to determine whether walking this distance with food waste buckets was convenient enough to ensure continued participation.

3.4.3.2 Discussion Round 2

The second discussion round dealt with questions 4-5 (Figure 3.8), relating to the selection process of participants.

The manner in which participants were selected partly emerged organically from the research process, and was partly decided upon by myself with the input of Tavener-Smith, a fellow ISUG researcher. This led to a mixed-method selection process. When the co-researchers were using bokashi in the pre-implementation phase, they had a number of residents show interest in bokashi and even asking where they could get a starter kit for themselves. The co-researchers had given positive feedback on the technology itself, and they were excited to start sharing it with their neighbours and fellow residents. This excitement on their part led them to pre-emptively tell some residents that they could be part of the pilot project.

Even though this was an unplanned method, intuition played a role in the decision to include the residents who had already shown some interest in the sample. The decision to include them rested on three overall facets of reasoning. Firstly, there was concern that excluding these residents, whom had already been told about the pilot and were interested to participate, may cause discontent and thereby stigmatise the project, which could affect other residents' willingness and motivation to participate. Secondly, the decision to include these residents allowed a certain process of self-selection to take place, which in itself was interesting to observe to see how much interest there was in using bokashi without knowing very much about it. Thirdly, it allowed the co-researchers to actively participate in the selection process, which I hoped would give them a deeper sense of being valuable role players in the design and implementation process, hence evoking a sense of ownership, enthusiasm and drive for the project.

The co-researchers felt confident that they would not have trouble finding a total of 50 residents who would be interested to partake in the pilot project, which they gauged on the interest they had received while using bokashi themselves. However, a somewhat

representative sample from all different sections of Enkanini was still needed. Therefore, the sampling methods were split into two; 50 participants would be selected through the self-selection process that the co-researchers orchestrated, and the other 50 participants would be selected through a computer-generated random selection process. The objective was to establish whether the distance to the ERC would make a difference in motivation to participate, and whether there was a difference in performance between the participants selected by co-researchers and the randomly selected participants. Performance would be measured by proper use of the bucket for intended purposes and correct use of the technology.

For the random sampling all shack numbers, except for those that had already been selected by the co-researchers, were entered into an Excel spreadsheet for stratified random sampling. This method was chosen, because Enkanini has been divided into nine sections that are different in size through an enumeration exercise undertaken by the Community Organisation Research Centre[16] in 2012 (see Figure 3.9). The stratified sampling was used to select a representative sample (2%) from each section. The 2% was based on a calculation that resulted in a total of 60 households being selected. 60 residents were selected, instead of only 50, in anticipation that some households may not be interested to participate or that they could not be located. Together with the 50 households selected by the co-researchers, this would theoretically make up the quota of 100 participants.

[16] The Community Organisation Research Centre is an NGO affiliated with the Informal Settlement Network, which in turn is the South African branch of Shack/Slum Dwellers International (SDI). SDI is a worldwide organisation that assists slum or shack dwellers to develop alternatives to eviction while also seeking to impact the global agenda for urban development. See www.sdinet.org for more information.

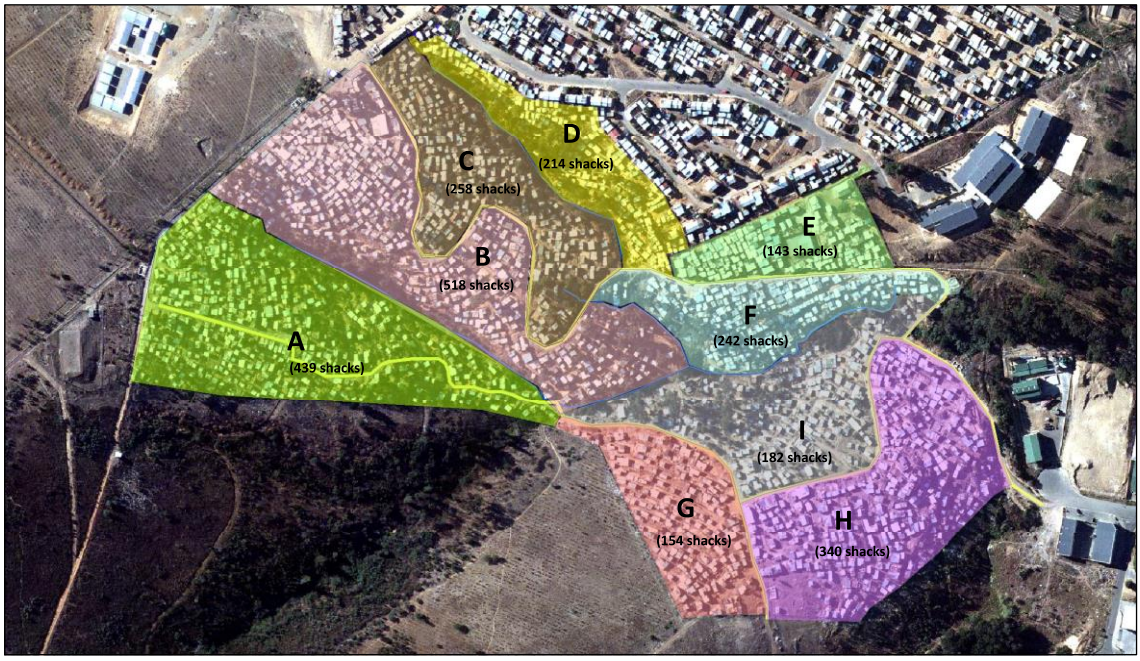


Figure 3.9 Sectional Map of Enkanini showing the nine sections.
Source: Community Organisation Resource Centre (2012)

The co-researchers contacted the people who had already shown interest in bokashi, to ask them whether they would still be interested in participating in the pilot project. If they were still interested, the co-researchers took down their names and numbers. Each co-researcher contacted at least 16 households and Tyawa found two more to make up a list of 50 potential participants. This list of 50 was therefore not proportionate to the different sections of Enkanini, because these were households who had more exposure to bokashi by living closer to the co-researchers. This sample, therefore, had 16 households in Section E, where Tyawa lives and 14 households in Section B, where Sileji lives. On the other hand, no households were selected from Section C as there had been no exposure in that section and none of the co-researchers knew residents living in that area (see Table 3.3 for a detailed list of households chosen by co-researchers).

Table Table 3.3 Sample of households chosen through the co-researchers and the stratified random sampling.

Section size	Stratified random sample (2%)	Self-selected sample
A – 439	11	2
B – 520	13	14
C – 258	6	0
D – 213	5	1
E – 143	3	16
F – 243	6	6
G – 154	4	2
H – 341	8	8
I – 182	4	1
Total	**60**	**50**

Once the list of households to be contacted had been put together, several days were spent walking around Enkanini, going door-to-door asking the randomly selected households whether they would like to participate in the pilot project. The co-researchers did most of the talking and explaining, while I only answered questions that they could not answer. A bokashi kit was taken along for demonstration purposes. Personal contact was made with 40 of the 60 randomly selected households. 19 of the 60 households could not be contacted, after several attempts to initiate contact on different days of the week, including a Saturday morning. One shack number was found not to exist even though it had been listed in the

enumeration report. 25 of the 40 households where personal contact was initiated were interested to participate and 15 were not interested. For the 19 households that were not reached personally it was decided to write a letter in Xhosa, explaining the project and inviting them to one of numerous information sessions taking place at the ERC. The telephone numbers of the co-researchers were listed, inviting the resident to send a 'Please Call Me' if they had any further questions. These letters turned out to be very ineffective and of these households only five joined us for an information session, and eventually only four of those five participated in the pilot project. Of the random sample that had been contacted personally and that had said they were interested in participating, 10 did not show up for an information session, hence leaving us with a total of only 19 randomly selected households that eventually participated in the pilot project.

Of the self-selected sample that the co-researchers had contacted and asked to come to information sessions, eight did not show up, which eventually left us with a sample of 42 self-selected participants who eventually participated in the pilot project. Hence, we had 61 households that were part of our original sampling list that showed up for information sessions and participated in the pilot project. Initially, only three different information sessions were set up, but when many of the households did not show up, it was decided to hold more information sessions to increase the chances of them being able to attend at least one of them. These information sessions that were held in the ERC attracted a lot of attention from other residents who stopped by to see what was going on. Some of them sat in on the information session and also wanted to participate. Because at least 15 households of the original sample had already said they were not interested in participating, this second group of self-selected households were slowly incorporated into the pilot project to replace these original households. After 12 information sessions a total of only 61 households of the original sample chose to participate, and the remaining 39 spots were given to these self-selected households who either heard of the pilot through others or saw that there was something happening at the ERC and decided to stop by to find out what it was. This selection method had certain limitations, which are discussed in Section 3.5.

3.4.3.3 Discussion Round 3

The third round of discussion dealt with the 'rules of the game'. Three aspects of the design had to be decided upon, namely

a. What should be done if a bucket has been lost or gone missing?
b. What days should collections and/or drop-offs take place?
c. How should the food waste be processed further and where should this?

Introducing the bokashi project to the participants at the information sessions launched the project. The information sessions were held at the ERC and were used to explain the logistical aspects of the project, and how to use the bokashi. At the end of the information session the households could decide whether they would like to take part in the pilot project, at which point they could collect a bokashi kit and their details were noted. All the buckets were numbered from one to 100 so that a certain bucket number could be linked to a certain household to help keep track of not only the bucket, but also how many times a household would drop off food waste and how much food waste they were producing.

Tyawa took over most of the explaining in Xhosa during the information sessions, while I only spoke to welcome the households and introduce the project to them. In my welcoming speech, I introduced myself as a researcher and explained the research interest in waste management. The waste characterisation study, which indicated that the majority of waste being produced in Enkanini was food waste, was explained and the problems food waste could create in the current waste management system was discussed, thus bringing about this intervention. It was made clear that this intervention was an experiment and that feedback on the technology as well as the set-up of the pilot was welcomed. It was also made clear that participation in the pilot project was completely voluntary and they were free to leave the session without feeling obliged to participate.

Tyawa explained how to use bokashi and that participants would be able to come each Saturday morning, between 9:00 and 12:00 to drop off their buckets at the ERC. The three co-researchers and I would be there to empty the buckets into bigger drums, and clean their buckets to hand back to them. They could also get more bokashi substrate at these times, if theirs had run out. Sileji and Mthelo also spoke during the sessions, explaining some of the details and answering questions. Some of the more common questions posed were on what would happen with the food waste and whether we would be making any money from it.

Another very common question was whether there would be any incentive to participate. The incentive is covered in the Section 3.4.3.4.

As there was a high expectation amongst actors, that buckets would be used for other purposes, a decision had to be made as to what to do in such a scenario. Residents showed a lot of interest in the buckets and stopped us as we were walking through the settlement while contacting our sample to ask us whether we were selling the buckets. Upon asking them what they would use them for most answered that they needed buckets for carrying water or that buckets were generally very useful. This added to the concern that the pilot participants may use the buckets for other purposes as they were obviously in high demand.

The buckets were the property of the municipality, and even though participants were not directly informed of this, an effort had to be made to convey that these buckets were meant for a very specific purpose and that if they were not intending to use the bucket for this, they should not participate in the project. Households were informed that if they participated in the project but it was noticed they were using their buckets for other things such as carrying water, the buckets would have to be returned. Participants were also requested to look after their buckets carefully, and not let them go missing or get stolen.

One of the objectives for the pilot was to try closing the loop on food waste by finding out how much waste could be processed locally without having to involve transport. Closing the loop is discussed in more detail in Chapter 4. There was some space available at the ERC, which was available for use to compost as much of the food waste as possible. In the theoretical design of the project it was hoped that the food waste could be used to make compost, which in turn could be used to grow food gardens, and the vegetables from the food gardens could then be given back to the participants or sold to other residents. Profits from that could be shared amongst the participants. This was a theoretical idea to link food waste to food security, and thus closing the loop, as will be discussed further in Chapter 4.

In an effort to link our food waste project to small-scale food production, a food gardening course with a man named Cobus Smit was organised. Smit has been teaching courses on food gardening for many years. He is based in Stellenbosch and is involved in the community garden in Kayamandi called Legacy. Smit has also been using bokashi in his gardening courses for several years and likes using it, as there is a visible difference in the quality of the soil that has been supplemented with bokashi (Smit, 2012). The soil in Kayamandi and Enkanini has very high clay content (Smit, 2012; Kotze, 2012), and growing vegetables in

clay soil is difficult. Smit has been supplementing the soil at Legacy Community Garden with bokashi for several years already and demonstrated the different soils during a field trip to visit Legacy. There is a visible difference in the texture and colour of soil that had been supplemented with bokashi food waste – it is much darker and not as compact compared to the soil that had not been supplemented with bokashi. Several experiments have shown that bokashi food waste produces high-quality compost (Lee, [n.d.]) and augmenting soil with bokashi food waste, either as a composted product or as a fertilizer, increases not only soil quality (Koh *et al.*, [n.d.]; Merfield, 2012), but also crop yield (Kahl & Daly, [n.d.]; Merfield, 2012). Improving soil quality is valuable for the future of agriculture, as modern agricultural practices have gradually degraded soil quality over time through the monocrop method as well as through the use of pesticides and herbicides, which has reduced the levels of organic matter in the soil (Lampkin, 1990).

3.4.3.4 Discussion Round 4

During the last discussion round, the last of the pilot design aspects was discussed, namely whether an incentive should be included in the project, as a motivation for participants and what it should be.

Haider first raised the question of whether an incentive should be provided to households to raise participation in this project. The reason why Haider and other actors, such as the co-researchers, believed an incentive was vital in the project relates back to the doubt they experienced whether households would be motivated enough to participate in the project and adopt this method. The co-researchers, for example, believed that there is expectancy amongst Enkanini residents of receiving a direct material reward for participating in a project and that participation rate would be very low if no such reward would be offered. The field trip to Hout Bay to view the social enterprise TrashBack (see Chapter 4) also indicated that an incentive scheme worked well and that it could raise the participation rate.

Andrew McNaught (2012), one of the founding members of TrashBack, claims that when they first started their recycling operations they thought the most convenient option for people would be a door-to-door collection. They also believed that they would be able to make a bigger impact on removing recyclables from the waste stream if they employed people that lived in the community to perform these door-to-door collections. However, what they soon found out was that residents did not want to give their recyclables to the collector when they found out that he would be ‘making money’ from it (McNaught, 2012). The residents did not agree to allow only the collector to benefit from ‘their’ recyclables without

getting a share of the value (McNaught, 2012). This showed that the collection in itself did not have any perceived value for the residents in this instance, but that there seems to be a misperception of the value that recyclables have (McNaught, 2012). According to McNaught (2012) people were often surprised or dismayed at how little monetary value a big bag full of recyclables actually had. With this feedback and a failed first attempt at a recycling operation, McNaught and his partners decided to rather work on a drop-off basis with a points-based incentive scheme. In this way, it was left up to the residents whether they wanted to trade in the value of their recyclables and drop it off at the centre themselves or let someone else trade in the value by giving the recyclables to them.

The experience that TrashBack has had in their collection trials spoke to the co-researchers' feeling that residents will probably expect an incentive if they are "giving us their food waste" (Mthelo & Sileji, 2012). After careful consideration it was agreed that an incentive, or reward in this case, could be justified to engage more participants and consequently render a clearer example of how a cleaner and healthier living environment can be achieved by diverting food waste. Also, they would be expected to walk a range of distances with a heavy bucket to drop off their food waste rather than having it collected.

The points and voucher system that TrashBack used was initially considered as the incentive set-up. However, this idea was rejected, as it would not be fair to allocate points related to the amount of food waste that is dropped off because some households are larger than others or may cook more than others. It would therefore be difficult to single out individual top performers by the number of times they dropped off their bucket or based on the amount of food waste they dropped off. It would reflect participation in general, but was not a marker of higher performance. Performance could be measured by correct separation of food waste from other waste and whether enough bokashi substrate was being used; in other words, by whether the technology was used correctly. It was suggested that this could be a performance indicator that could be used as a gauge to measure reward. Basing incentives on proper use of technology might also motivate participants, as there were concerns that there would be much digression from proper use.

The question of incentives was discussed at a meeting in Enkanini with the co-researchers and Kotze from AgriProtein. As mentioned before, Kotze joined the meeting out of interest to hear how the pilot would be implemented, and the possibility of processing food waste using the BSFL was discussed at more length. Various incentive schemes were covered and advantages and disadvantages were discussed for each. Basing incentives on proper use of

technology and rewarding top performers through this was debated first and it was concluded that picking out top performers in any way would not possibly lead to jealousy or be a demotivator rather than a motivator. Kotze made a suggestion to hold a barbecue event, also known in South Africa as a 'braai', for all participants instead of individually rewarding participants through vouchers or only rewarding top performers. In his experience of doing community projects working for AgriProtein, braais seemed to be very popular (Kotze, 2012). There was consensus between co-researchers that a braai would be an appropriate incentive and that rewarding everyone equally was a good way of thanking all the participants for their effort.

3.5 Limitations

At the beginning of the study, certain limitations that could influence the research process and its outcomes were identified, namely:

1. There would be unavoidable language, cultural and class barriers that are rooted in a white middle-class South African conducting research in an informal settlement.
2. This was the first time I would be conducting research in the subjects of waste management and informal settlement upgrading, and it is acknowledged that this would have some bearing on the study itself and its outcomes.
3. The available time frame of 18 months in which to conduct the research may be too short to complete a full circle of TD research phases in which full integration of transformation knowledge would be achieved.

These limitations were dealt with in the following ways:

1. Close relationships with stakeholders were formed, especially with the co-researchers, in the hope to establish a sense of trust and understanding to circumvent issues such as language, class and cultural barriers.
2. By implementing TD methodology in this study, the use of TD principles enabled me to conduct research across disciplinary boundaries without diminishing scientific rigour, therefore circumventing the limitations of lack of disciplinary knowledge.
3. By acknowledging that transformation knowledge was not fully integrated, further research opportunities are indicated that can be conducted by another ISUG researcher in future.

A further limitation in the study was the selection method used to select households for the pilot project. The chosen selection method may influence the generalisability of the study in that the findings may not be applicable to the whole population of Enkanini. The first problem is that the sample was very small and only comprised 4% of the total number of households in Enkanini, and thus the findings may not be applicable to all of them. The second problem is that 81% of the final sample of participants consisted of self-selected households. Thus, the results of the pilot project would be influenced by the high rate of self-motivation present in the sample. The self-motivation relates back to tacit knowledge and, as will be elaborated on in Chapter 4, residents with higher levels of tacit knowledge will usually be the first adopters of a new behaviour (Darby, 2006). If the pilot project had included a more even representation of self-selected and randomly selected households, the results may have differed, similar to a sample that would have consisted of only randomly selected households. This is to be kept in mind when interpreting the results of the project.

3.6 Conclusion

This chapter has given an overview of the methods used in the study and divided them into the three phases of a TD study. The first phase covered methods of contextualisation that embedded the research process within the life-world. Through this, three preliminary questions were established and the answers to these helped to identify the life-world problem that needed to be researched, thereby establishing systems knowledge and determining the main research question. The entire process was a reformulation of the initial research problem that had been put forward in the initial research proposal. This was done before contextualising the study within the life-world. This means that the initial idea to focus the study on attitudes and behaviour was reformulated to speak to the needs of the stakeholders in the life-world and their relevant problems.

Following this, methods of knowledge integration through the use of boundary objects in Phase 2 helped to establish target knowledge. Establishing knowledge is differentiated from integrating knowledge in this study, in that establishing knowledge refers to knowledge that is only rooted in the theoretical paradigm of ideas and notions. Integration of knowledge refers to rooting knowledge in tacit and explicit knowledge. The boundary objects that were used in this phase helped to establish target knowledge, which led up to the intervention in Phase 3, which in itself was a boundary object that achieved the integration of target knowledge.

Phase 3 was described by explaining what the intervention entailed and how the design of the intervention was decided upon. The bokashi experiment was explained and the decisions on the finer details of the pilot project were described, such as choosing between collections versus drop-offs and implementing incentive schemes.

Chapter 4 Findings

4.1 Introduction

The findings in this chapter are presented according to the framework that was established in Chapter 1, and speak to systems, target and transformation knowledge in the various phases of a TD study. The findings to the preliminary and sub-questions are discussed in the same order as they emerged during the research phases. The chapter concludes by discussing the overall aim of the study and the main research question to tie together the research process under the main theme.

Section 4.2 of this chapter will speak to systems knowledge and investigate the findings to the preliminary questions. The objective of this section is to populate systems knowledge to inform an understanding of both theoretical concepts and lived experiences, and subsequently to facilitate connections and translation of perspectives and knowledge to move from systems to target knowledge. Theoretical concepts, the first part of systems knowledge, were covered in the literature review in Chapter 2 while the second part of systems knowledge, the anecdotal elucidations of the lived experiences of both Enkanini residents and municipal representatives, will be examined here, under the headings of the three preliminary questions:

1. What are the problems with the current waste management system in Enkanini that are of social, environmental and economic concern, and what is the broader context, on a town level, within which it is embedded?
2. What kind of waste is being generated in Enkanini?
3. What are some of the alternative waste management (treatment) systems for low-income areas and informal settlements that are being implemented by municipalities, the private sector and civil society organisations in South Africa?

Section 4.3, categorised under Phase 2, describes how target knowledge was established and what the target knowledge consisted of. Establishing target knowledge is distinguished from integrating target knowledge in that establishing target knowledge is still only embodied in theoretical ideas and goals rather than in tacit and explicit knowledge. Tacit knowledge is an unconscious, practical type of intelligence created through everyday experiences and preludes explicit knowledge, which is a conscious knowledge of facts (Darby, 2006). I posit that integration of knowledge only takes place when it is embedded in both tacit and explicit knowledge, and therefore needs to be accompanied by action. Action only took place in

Phase 3 in the form of the pilot project and was therefore the tool through which tacit and explicit knowledge was populated. This was followed by the integration of target knowledge.

Section 4.4 covers Phase 3, in which the pilot project was implemented. The first part of this section lists the components of the pilot project, while the second part reflects on the outcomes of the bokashi pilot project, analysed through the sub-questions. The bokashi project is a system that was implemented within the current system, but was kept independent from the operations thereof. For purposes of project continuation, replication or expansion, the components required for this project are listed. The sub-questions that guided the bokashi pilot project were:

1. What is the participation rate in the pilot project?
2. What are the benefits and shortcomings of this particular waste treatment method from the perspective of Enkanini residents and the municipality?
3. How much food waste can be diverted from landfill through the alternative processing method?
4. What are the costs of the alternative processing method and are these feasible compared to current costs?
5. Did social learning take place and does this have an impact on the broader context of Stellenbosch's waste system?

The findings based on these questions help to answer the main research question (at the end of this chapter) and reach the overall aim of the study, namely evaluating whether bokashi is an alternative waste management system that is implementable in Enkanini and could ensure social, economic and environmental sustainability.

4.2 Systems knowledge established (Phase 1)

This section describes the findings for the preliminary questions, which were answered through actions of contextualisation described in Chapter 2 and make up three of the four components of systems knowledge as depicted in Figure 4.1. The high-level intent for Phase 1 was to facilitate connections and translation of perspectives and knowledge to move from systems to target knowledge.

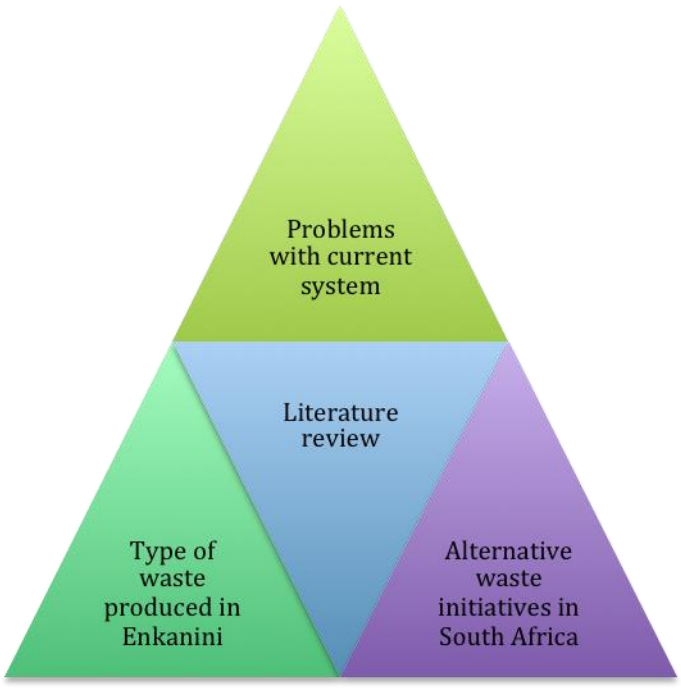


Figure 4.1 The four components that makes up systems knowledge in this study.

4.2.1 Problems with the current waste system in Enkanini

To keep to the intent of Phase 1, the first step was to establish the status quo for the waste management system in Enkanini. The corresponding preliminary question is: *What are the problems with the current waste management system in Enkanini that are of social, environmental and economic concern, and what is the broader context, on a town level, within which it is embedded?* This question was analysed and answered through observations and interviews that all formed part of the communication processes established with stakeholders and actors (detailed in Chapter 2). Acquiring this systems knowledge helped to contextualise the study within the life-world, as understanding of the problems of the current waste management system as seen from the perspectives of the different stakeholders deepened.

In populating systems knowledge, a short summary of the current waste management system is given here but will be elaborated on in detail in the following section. There are seven concrete waste bays also known as MTSs, placed throughout Enkanini. Residents are supposed to throw their solid waste into these concrete bays and the waste should be collected once a week by the municipal waste collection service. The concrete bays were built sometime between 2010 and 2011 as can be seen from Google Earth satellite images. The settlement was first established in 2006, starting with just a few shacks but expanding

dramatically between 2009 and 2010, hence bringing about the construction of the concrete bays (Petersen, 2012).

Table 4.1 below summarises the problems of the current waste management system according to perspectives of different stakeholders. The column entitled 'Systems knowledge' summarises the status quo that was established as part of Phase 1. The aspects mentioned in column entitled 'Target knowledge' emerged in Phase 2 and formed the objectives the group of stakeholders wanted to achieve through the pilot project. The points in each column were gathered through individual interviews, group discussions and meetings such as the SITT.[17]

[17] For a description of SITT, please see Section 3.2.2.1.

Table 4.1 Systems and target knowledge from a stakeholder perspective.

Stakeholder	Systems knowledge	Target knowledge
Enkanini residents	1a) The current waste collection system in Enkanini encompasses seven concrete waste bays, also known as mini-transfer stations, which are low-tech but cause more waste related problems than they solve by being too few and far between for residents. It is open to the elements such as rain, which adds further complications to cleaning up the waste, and wind, which can pick up loose bits of waste and spread it across the settlement. It attracts rats and other pests as concrete bays are not enclosed. It is ill-suited for waste separation and recycling, therefore containing food waste which contaminates the remainder of the solid waste as well as the recyclables. This minimises potential value that could be harnessed through recycling.	1b) Implementing an intervention that is not only low-tech for easy adoption by residents, but also addresses as many of the problems with the current system as possible.
Enkanini residents & Stellenbosch Municipality	2a) Despite regular waste removal services falling under the municipality's legal obligations, waste collections for Enkanini are performed on an irregular basis and concrete bays remain full for extended periods of time. This leads to putrefying waste.	2b) Regular waste removal or an alternative system that does not have such extensive negative impact if not collected regularly
Enkanini residents	3a) Solid waste can have some monetary value if processed correctly. However, this value is currently being lost instead of being captured by Enkanini residents.	3b) What beneficiates waste, whereby (as far as possible) the benefits are kept within the boundaries of Enkanini.
Stellenbosch Municipality	4a) The Stellenbosch municipal waste collection system is not only costly, but overloaded as well and cannot cope with co-ordinating logistics for additional management schedules (Haider, 2012).	4b) What does not place additional strain – or even reduces pressure – on the municipal waste collection system.
Stellenbosch Municipality	5a) The Stellenbosch landfill exceeds its legal height limit and the new cell has a very short life-span, after which all solid waste will have to be transported further away with high cost implications, hence making the promotion of recycling and reuse a municipal priority in order to increase the landfill life-span by as much as possible	5b) What reduces the amount of solid waste taken to landfill.

The aspects detailed under systems knowledge are problems related to the outcomes of Phase 1 in which the status quo was established, including the problems of the current waste management system in Stellenbosch. These were established through embedding the study in the life-world and engaging with stakeholders and actors in open encounters, conducting interviews and observing the status quo. The problems of this are detailed in the following paragraphs under 1a to 5a, corresponding with Table 4.1.

1a) Problems associated with the Enkanini waste management system

In conversations with residents and with the co-researchers it was established that the seven concrete waste bays are not sufficient to service the 2500 households in Enkanini, as they are too far apart to put them in convenient walking distance for many residents (see Figure 4.2). When the concrete bays were constructed, they were placed in locations that at the time were most easily accessed by waste collection trucks (Petersen, 2012). The only consideration with placement was ease of access for trucks, and in effect the concrete bays are unevenly placed within the settlement, putting many residents far from a concrete bay (see figure 4.2).

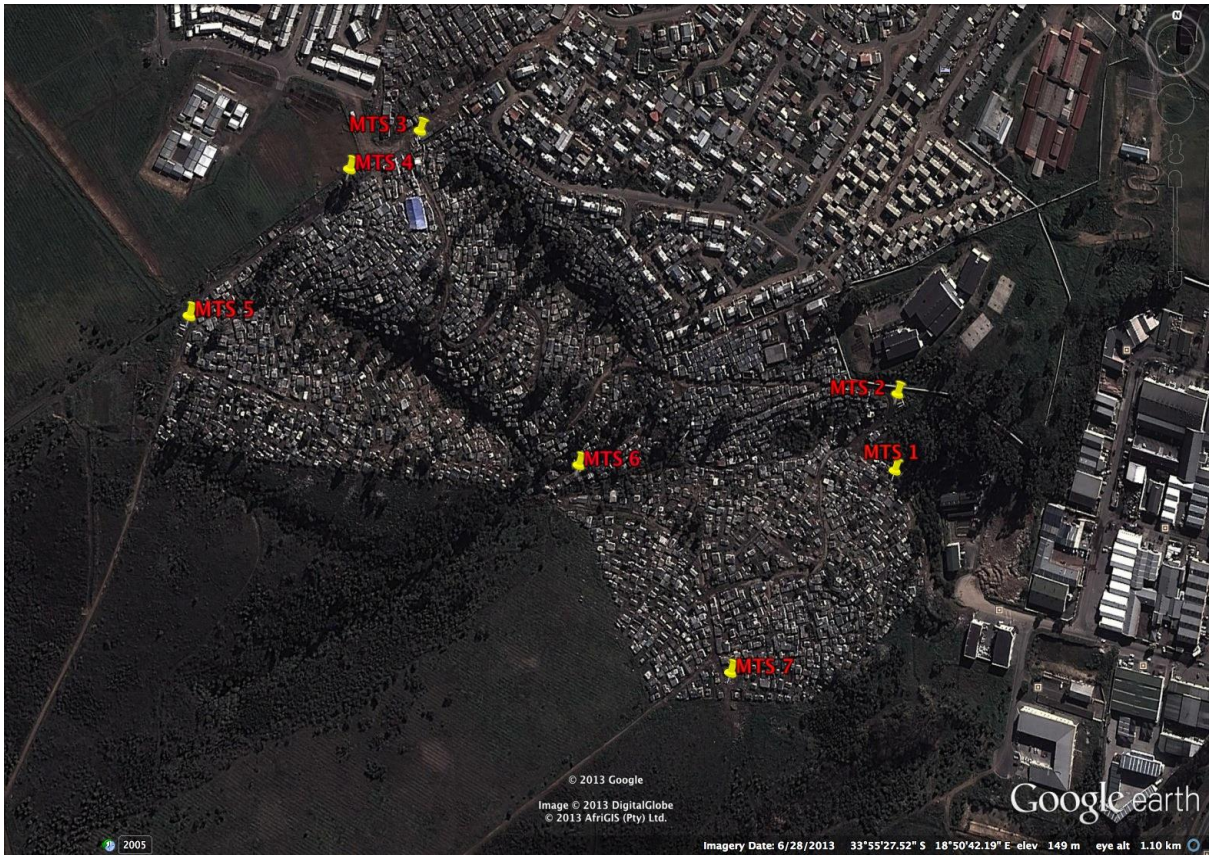


Figure 4.2 Location of Municipal Transfer Stations (MTS), or concrete waste bays.

Source: Google Earth. 2013. [Online] Available: http://www.google.com/earth/. GPS co-ordinates: 33°55'28.18"S, 18°50'41.57"E. [20/10/2013]

This leads to waste being thrown into non-designated areas, which are sometimes even more difficult to reach for collection and cleaning. One such area, for example, is located on the eastern border of Enkanini where surrounding households have taken to throwing their rubbish over the fence (see Figure 4.3). This area is inaccessible to waste trucks and hence waste accumulates for many months before the municipality sends waste pickers to manually collect the waste, place it into black bags and carry them down to the nearest road – an expensive and labour-intensive operation (Petersen, 2012).

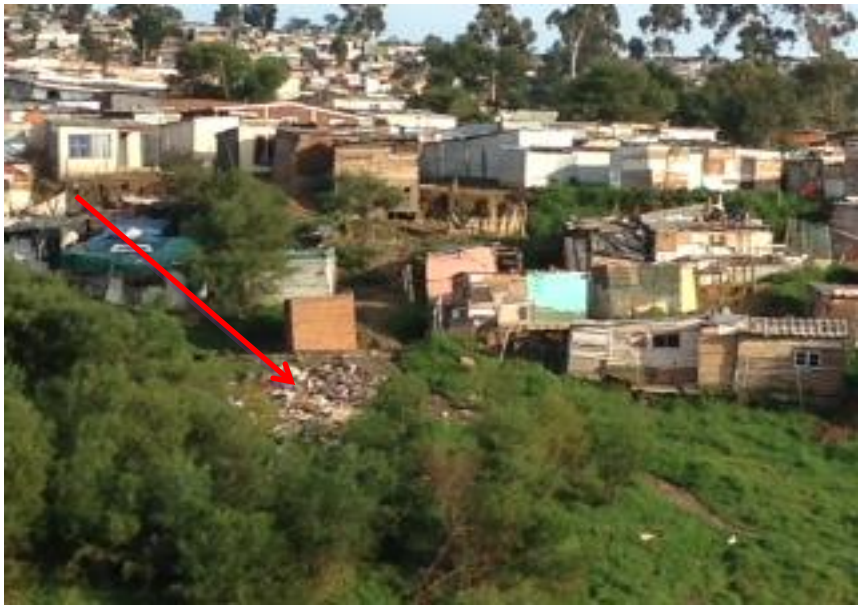


Figure 4.3 Eastern border of Enkanini depicting a dumping site in a non-designated area (photograph taken by author, 2012).

Another problem with the current concrete bay system is that these bays are open to the elements from the top and accessible to pests from the side (see Figure 4.4 below). Waste gets wet when it rains, which leads to run-off that is contaminated, and the wet waste putrefies quicker, which leads to more pest attraction. Residents also claim that the wet waste is a breeding ground for mosquitoes (Galada, 2012) and an excellent environment for rats to breed. The south-east wind, which is infamous in the Western Cape for its force, sweeps through Enkanini and loose pieces of rubbish, especially light plastics, are swept up and spread around the settlement and surrounds. The rubbish is often loose, as black refuse bags are not a priority item to spend money on for this low-income community (Tyawa, 2012). The municipality claims to hand out refuse bags free of charge when the waste collection trucks pass through the settlement (Petersen, 2012), but according to the co-researchers this happens very seldom and without regularity (Tyawa, Sileji & Mthelo, 2012). The municipality has also come across the problem that when they hand out black bags to Enkanini residents, the bags are sometimes used for purposes they were not intended for, for example sealing off holes in shack structures (Haider & Petersen, 2012).

Figure 4.4 One of the seven concrete waste bays in Enkanini (photograph taken by author, 2012).

The structure of the concrete bays also makes it ill-suited to any separation or recycling activity, as waste is not separated at the source.[18] Thus the food waste and hazardous waste, such as animal carcasses and baby nappies containing human faeces, contaminate any possible recyclables (see Figure 4.5). The lack of refuse bags aggravates the problem of an exposed concrete bay and also contributes to the difficulty in separating and recycling. This means that most of the potential value that could be harnessed from the recyclables is lost and all waste collected from Enkanini has to be taken to the landfill. Haider, and Gavin Glick from the private waste company, Tedcor,[19] both claimed that in their experience the waste coming out of informal settlements is "the dirtiest waste" they deal with (Haider, 2012; Glick, 2012). 'Dirty' is meant in the literal sense as it has, in most cases, had a chance to putrefy, and has been exposed to the elements, but also because waste that is classified as hazardous is found in these concrete bays as well, for example animal carcasses and human faeces (Glick, 2012).

[18] 'Separation at source' refers to the separation of waste categories at its source of generation, in this case at household, or consumer, level.

[19] Tedcor (Pty) Ltd is discussed in detail in Section 4.2.3.1.

Figure 4.5 Waste accumulation in MTS 7, the same concrete waste bay depicted in Figure 4.4 (photograph taken by author, 2012).

2a) Irregular waste removal

The second problem indicated in Table 4.1 is irregular waste removal in Enkanini. By physically being present in Enkanini and spending time walking around and meeting with co-researchers, I was able to observe the status quo of the waste management system, have informal discussions about it with residents and have formal discussions about it with the co-researchers. Through this, and through observation, I was able to determine that waste is collected irregularly. The desktop research for this study took place in an office in Plankenbrug, with a view overlooking the informal settlement (see Figure 4.6). This office had a good view of two concrete bays in the settlement (MTS 2 and MTS 7 were visible, as an incline and vegetation prevented the view of MTS 1), and thus I was able to easily see every weekday for a six-month period whether the waste was being collected on a regular basis. It was established through this observation that often several weeks would pass before a waste collection truck came into the settlement and that there seemed to be no regularity in collections at all. The time between collections ranged from weekly (as mandated), to two months.

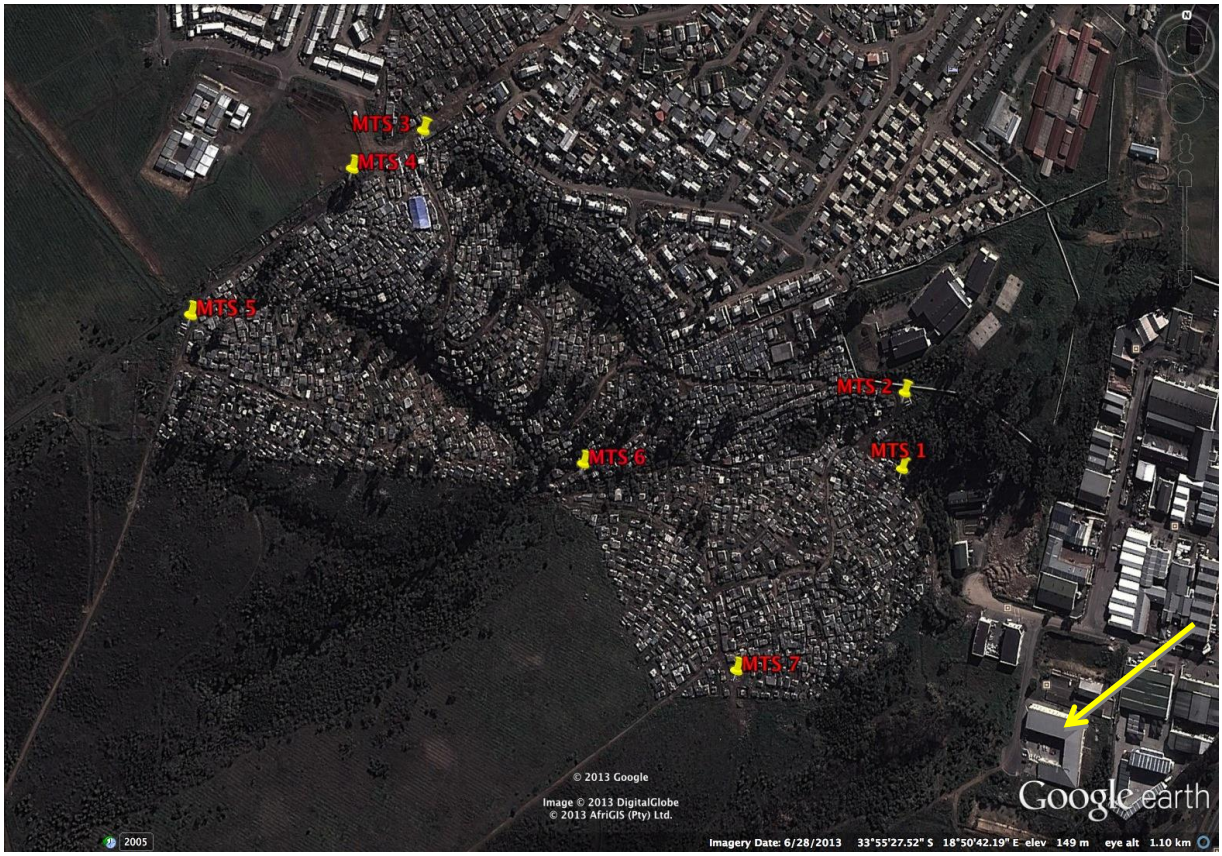


Figure 4.6 The office from which desktop work was done, indicated by the yellow arrow, had a view of MTS 2 and MTS 7.

Source: Google Earth. 2013. [Online] Available: http://www.google.com/earth/. GPS co-ordinates: 33°55'28.18"S, 18°50'41.57"E. [20/10/2013]

The irregularity of collections was confirmed by several residents (Pamana, 2012; Nomvilisu, 2012), as well as by the co-researchers, of whom Mthelo lives right next to one of the badly serviced concrete bays. Mthelo (2012) claimed that waste from certain bays located further into the settlement, like the one he lives close to, does not get collected for months on end. He did not know why this was the case, except that he assumed that sometimes municipal workers did not feel safe to enter the settlement because of tensions between residents and the municipality, which lead to threats against anyone associated with the municipality (Mthelo, 2012). The lack of regular waste removal from that concrete bay was visible by the amount of litter lying in and around it (see Figure 4.5 above and Figure 4.7 below).

Figure 4.7 The area next to MTS 7 that is used as an additional dumpsite when MTS 7 is full.
Source: Conway (2013)

The conflict between Enkanini residents and the municipality around issues such as the lack of electricity in the settlement, has therefore affected the regularity with which the municipality services Enkanini for waste collections. Van Niekerk (2012), the town engineer, confirmed this, as well Haider (2012), the manager and Ebrahim Petersen (2012) the principle technician of the solid waste department. Petersen (2012) stated that municipal workers feel that their safety is threatened when coming to Enkanini and some had experienced physical aggression exhibited towards them, such as residents throwing rocks at the waste trucks. Thus, in times of exacerbated upheaval and instability, such as during protests or political elections, municipal workers do not enter Enkanini to remove waste because they fear for their safety. This leads to interrupted service periods.

When asked if there were any other reasons the municipality did not collect as regularly as their schedule proposed, Petersen (2012) stated that often the dirt roads are in such poor condition that it prohibits the waste collection trucks to drive up into the settlement,

especially during the rainy season. Haider (2012) added that the solid waste department is understaffed and therefore often lacks human capacity to perform all waste collections regularly. The first area to be left out in such a case is Enkanini, as the municipality's priority lies with rates and taxpayers, which Enkanini residents are not. These reasons further contribute to interrupted service periods in Enkanini.

Due to the irregular waste removal at Enkanini, residents often decide to take matters into their own hands by burning the rubbish once it has accumulated for a number of weeks, as was personally witnessed on numerous occasions. The irregular service is also another reason why residents do not throw their rubbish only into the concrete bays, but often throw their waste into non-designated areas (Tyawa, 2012). The other reason for this is because the bays are in inconvenient locations in relation to where they live, as discussed above. As both Jaco Botha and Gavin Glick (2012), two managers at Tedcor (Pty) Ltd experienced, a regular waste service is all that is needed to garner support and participation from residents, because complying with the requirements for a service that does not work properly is senseless.

In summary, waste is not collected regularly for three main reasons. These are: (1) unrest sometimes prevents municipal workers from entering the settlement, (2) road conditions are sometimes so poor that waste collection trucks are unable to drive into the settlement and (3) when the municipality is understaffed, Enkanini is one of the first areas to be left out of the waste-removal route as residents here do not pay rates and taxes. This leads to extended periods of interrupted waste removal services, leading to waste accumulation in concrete bays and other non-designated areas.

3a) Waste is not beneficiated

The third point in Table 4.1 deals with lack of waste beneficiation. The status quo at the moment in Enkanini, as can be easily observed, is that waste is not being beneficiated, as was already alluded to in point 1a, which discussed the recycling potential of the current system. Waste is usually thrown out, and consequently very few people benefit from this potential resource, which could be harnessed through recycling projects, composting projects, or even recycling projects such as making arts and crafts out of waste material, similar to the Sikelela

Skills Development Centre in George.[20] Although there is not a lot of value in waste (Houghton, 2012), there is enough to create a few jobs, or for participants to receive some petty cash from activities such as recycling, as the organisation TrashBack[21] has demonstrated. The problem with recycling is that margins are very small and thus big quantities are needed to make a profit, which would require a larger infrastructure, such as a sorting and storage facility located in an easily-accessible area that trucks can access to collect the recyclables, and a forklift truck to load the recyclables onto the collection truck (McNaught, 2012; Glick, 2012).

Composting, another beneficiation method, is more complex than recycling, as it requires more infrastructure and has thus not been attempted by NGO and government initiatives as much as recycling initiatives (McNaught, 2012). Depending on the type of composting, infrastructure ranges from drums to heavy tractors. Some composting methods require heavy machinery while most methods require a substantial amount of space. If composting is chosen as a beneficiation method where compost is to be sold, the compost will ideally need to be of consistent quality in order to enter the market at competitive rates (Houghton, 2012; Van der Merwe, 2012).

4a) Costly waste management system

Through interviews and conversations with Haider, as well as attending the SITT meetings, it was ascertained that the solid waste department is facing numerous problems, which will be detailed here and under point 5a. With little data available from the municipality on their waste management system, it was primarily through these meetings and interviews that the problem listed under point 4a, in Table 4.1, was brought to light. However, in March 2013 the municipality commissioned an economic feasibility study, which was compiled by Martin de Wit of De Wit Sustainable Options (Pty) Ltd. This study gave the results of a waste cost systems model, which was used as a backup to confirm retrospectively what had been ascertained in interviews and meetings during Phase 1 of the research process. Therefore, the following paragraphs will be a combination of both sources of information, despite the time

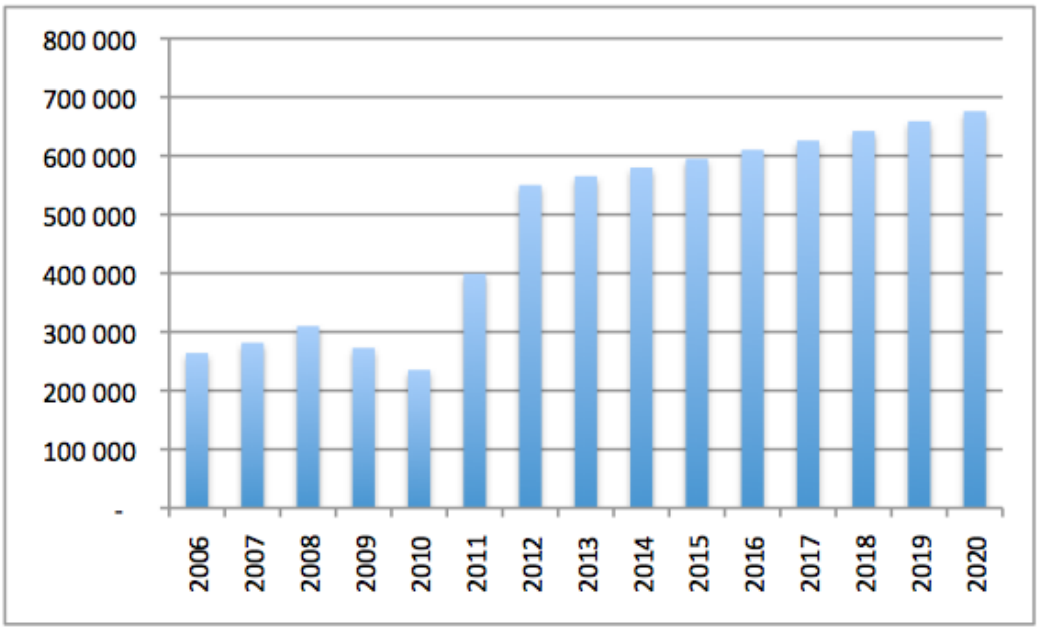
[20] The Sikelela Skills Development Centre in George is a job creation initiative started in 2006 that aims to teach unemployed people craft skills by making arts and craft pieces out of recyclable waste material, such as plastics, textiles and glass. The centre was visited briefly while on a trip to the area to visit family.

[21] TrashBack is discussed in Section 4.3.2.2.

lag between establishing the problem in Phase 1 and de Wit's economic feasibility study almost a year later.

One of the most pressing problems regarding waste management in Stellenbosch is the serious landfill constraint that this town faces (detailed under 5a). The Stellenbosch landfill was only recently closed for operations after growing several meters above its legal height limit (Haider, 2012), and the new cell that has started operating mid-year in 2013 next to the old site is estimated to only last 20 months until it will also reach maximum capacity (De Wit, 2013). Both sites are located on the outskirts of Stellenbosch in Devon Valley. The current composting and recycling initiatives in Stellenbosch do not divert substantial amounts of waste from the landfill and therefore have an insignificant impact on waste diversion from the landfill (de Wit, 2013). Haider stated in several interviews that the solid waste department is seldom allocated enough money to make it to the end of the financial year and that the real costs of waste management in Stellenbosch are not fully appreciated in that tariffs, and rates and taxes are still too low to cover the costs of waste management, despite the 8.5% increase from last year (Haider, 2012).

In the 2010/11 financial year it was reported that the total cost of solid waste management in Stellenbosch was R72 million (De Wit, 2013). Disposal tariffs at the landfill are at R136.16 per ton for general waste in 2013 compared to R333.20 per ton for general waste in the City of Cape Town, and household tariffs for Stellenbosch in 2013 are at R88.06 for one wheelie bin, or three black bags per week compared to R103.30 per wheelie bin in the City of Cape Town. Added to this is a recent spike in landfill volumes accepted at the Stellenbosch landfill from around 230 000 tonnes per annum in 2010 to 550 000 tonnes in 2012 (Figure 4.8), with no information on exact volumes or the source. Haider has speculated that other districts, not even under the jurisdiction of Stellenbosch, transport their waste to this landfill because of the cheaper tariffs.



Source: Stellenbosch Municipality
Note: 2009 is estimated as the average of 2008 and 2010. Figures for 2013-2020 are estimated based on projected GGP growth.

Figure 4.8 Total municipal solid waste (MSW) landfilled (2006–2020) in tonnes per annum.
Source: De Wit (2013)

Although there was a lack of reliable data that could indicate the current state of Stellenbosch's waste management system at the time of interviewing Haider and participating in the SITT meetings, there was an overall consensus that the waste system was costly and not fully appreciated through rates and taxes. It was also estimated that servicing the 11 concrete waste bays in Enkanini and parts of Kayamandi costs around R2.9 million per annum to cover labour and cleaning of vehicles (De Wit, 2013). R2.9 million works out to only 4% of the total cost of the overall waste management system for Stellenbosch, so if the system worked properly this would most likely be a financially viable model. However, the system does not function properly and thus the money spent on this model could be put to better use.

5a) Serious landfill constraints

The problem of constrained landfill space, presented in Table 4.1 under point 5a, was already alluded to in the previous section, as it relates to the costs of the system. In interviews Haider pointed out that once the new cell that has recently gone into operation (June 2013) has also reached capacity, Stellenbosch will have to start transporting its solid waste to landfills or

transfer stations located much further away, which would have massive cost implications for the town. At the time of interviewing in 2012, Haider estimated that the new cell in Stellenbosch would have about a three to five year lifespan, depending on how quickly and efficiently waste diversion programmes could be set up, such as recycling and composting of organic waste. However, after the waste costing model was performed by De Wit (2013), the lifespan was cut down to only 20 months using current waste generation statistics, with continued recycling and composting inefficiencies in mid-2013 (De Lubbe, 2013).

The costing model evaluated five waste disposal options for Stellenbosch (De Wit, 2013). These were:

1. Baseline landfilling with composting and recycling;
2. Waste transporting to Kraaifontein Integrated Waste Management Facility (KIWMF);
3. Waste transporting to Klapmuts Transfer Station (KTS);
4. Development of a new cell at Stellenbosch Landfill;
5. Transport to Bellville South Landfill (BSL).

The results showed that developing a new cell is currently the most sensible option from a financial and spatial perspective, but this is a short-term option as the new cell only has a lifespan of 20 months before it reaches capacity (De Wit, 2013). However, all the options of transporting waste to sites that can handle the bulk of waste Stellenbosch generates, such as the BSL, KIWMF and KTS, are all extremely costly and therefore fall away as viable options. Furthermore, current baseline options of recycling and composting do not divert sufficient amount of waste from the landfill.

To summarise, all of the options evaluated by De Wit (2013) are more costly than current baseline landfilling options. This is problematic, as it will not encourage efforts of finding alternatives. Therefore, De Wit's report concludes with the strong recommendation that Stellenbosch conducts full-scale evaluations of alternative waste management options besides the current system and options tried thus far. These options need to fulfil the criteria of diverting sufficient amounts of waste from landfill and being financially feasible and sustainable. The report also recommends that these larger-scale interventions are required to be implemented within a short time period, hence urgency is present for alternative solutions to be sought and implemented in Stellenbosch.

4.2.2 Categorising waste in Enkanini

Once the problems with the current waste management system were established, a clearer understanding of the concerns with the current system emerged, as well as the broader context in which it was embedded and the constraints thereof. Due to the limited data the municipality has available on figures and statistics for their waste department, there was no information on the type or volume of waste that was being generated in Enkanini. Thus, the second preliminary question was established, namely "What kind of waste is generated in Enkanini?", and is covered in this section.

The type and volume of waste generated is valuable information for a municipality in order to make informed decisions on alternative waste management solutions and to plan ahead (Haider, 2012). Therefore, in June 2012 Haider ordered an extensive waste characterisation study to be performed for all areas that fall under Stellenbosch Municipality's jurisdiction. Haider knew at this point that I was doing my research in Enkanini and asked me whether I would be interested in helping with the waste characterisation study. I accepted this offer and was physically involved in collecting black bags from Enkanini and sorting through them, categorising waste items.

Included in this characterisation study was Enkanini but, unfortunately, the sampling for Enkanini did not run as planned because of multiple life-world factors that interfered, resulting in a very low sampling percentage for Enkanini, namely only a 2.48% sample of black bags for the entire settlement. The factors that contributed were the following:

The first problem that the team encountered was that at the time of this characterisation study the exact number of households that reside in Enkanini was unknown. This information only became available later during the year in the form of the enumeration report that was orchestrated with the help of the Informal Settlement Network (ISN) and the Community Organisation Resource Centre (CORC). This made it impossible to determine how many black bags would constitute a 10% sample and thus the team had to estimate that there were 4000 households in Enkanini; thus a 400-bag sample was needed. The sample fell short of this target and even though the number of households was overestimated by 38%, the 62 bags that were collected still only made up 2.48% of the 2500 households living in Enkanini.

The second problem was that usual collections for Enkanini are scheduled for either a Monday, Wednesday or Friday and, as explained in the previous section, the service is so irregular that it was difficult for Bradfield to know when the waste would have been picked

up, if at all. Bradfield had to coordinate all other areas into the waste collection schedule and hence scheduled Enkanini for the 6th of June 2012, a Wednesday morning. Unfortunately, the waste collection truck had come to do its round very recently, meaning that there were fewer bags to collect. This limited the sampling range quite drastically.

Lastly, only waste that was already in black bags was collected due to health and safety reasons. As mentioned already, Enkanini residents make very little use of black bags and thus the sampling range was limited even further. As many bags as possible were collected, but the team ended up collecting from only four of the seven concrete bays due to this, and only 62 bags were collected. The four bays from which we collected the black bags were MTS 1, 2, 5 and 7, as indicated in the Figure 4.9.

Figure 4.9 The black bags were collected from the concrete bays that are indicated by a yellow arrow.

Source: Google Earth. 2013. [Online] Available: http://www.google.com/earth/. GPS co-ordinates: 33°55'28.18"S, 18°50'41.57"E. [20/10/2013]

The results of the waste characterisation study showed that a high percentage of waste generated in Enkanini is organic, more specifically food waste. This is represented visually in Figure 4.10, which shows the percentage of waste categories in mass, and in Figure 4.11, which shows the percentage of waste categories in volume. In both instances, food waste

makes up the majority of the substrates gathered from the 62 bags. As food waste is relatively heavy compared to all other waste and is inversely relatively small in bulk, it is perhaps more significant that the results show that food waste also takes up the largest portion according to volume.

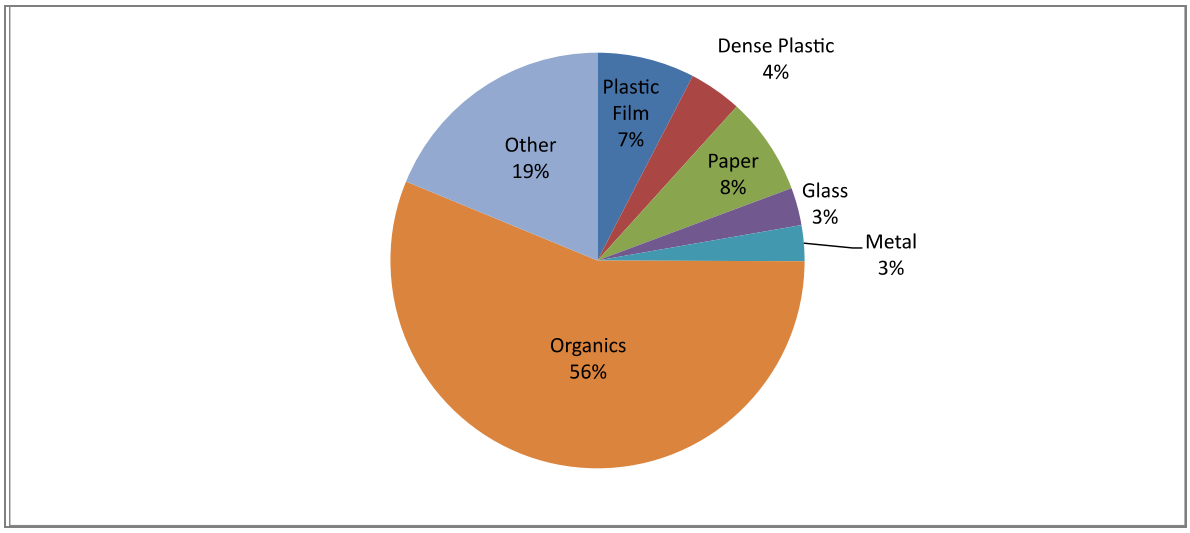


Figure 4.10 Waste generated in Enkanini, categorised by weight.

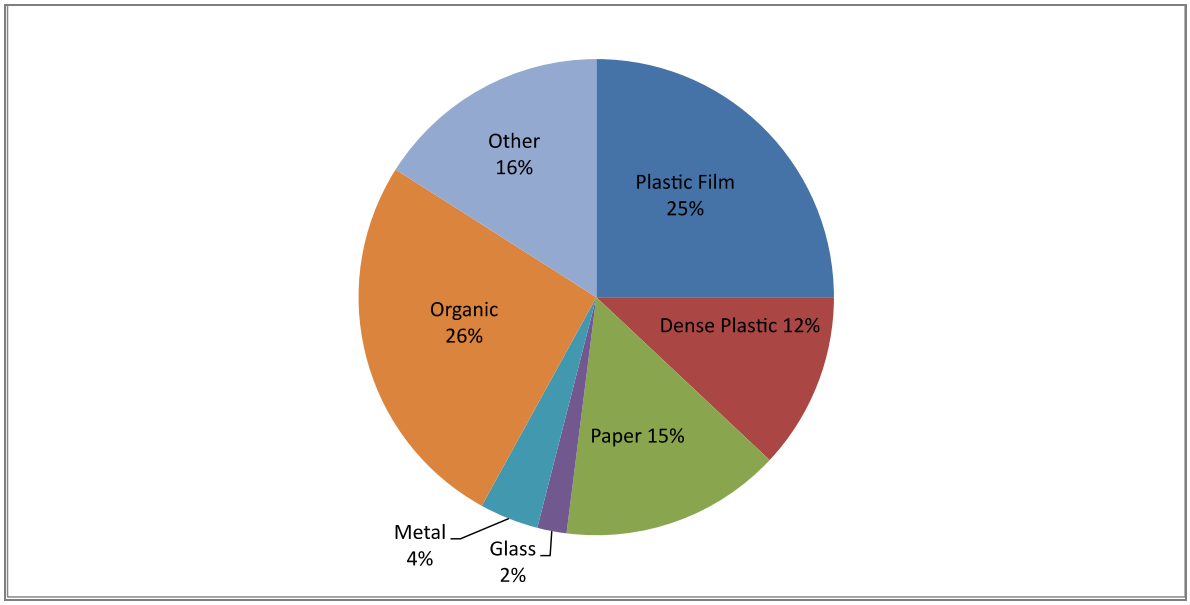


Figure 4.11 Waste generated in Enkanini, categorised by volume.

The results of this study were taken from a relatively small sample. Other studies show different results in terms of the percentage of organic matter relative to other waste streams in both high and low income areas (see Figure 4.12). Millard (2003 in Engledow, 2005) shows

that the highest portion of waste in informal settlements is inorganic matter (inert material such as ash, rubble and sweepings), followed by organic waste (made up of food and green waste) at 20 percent, and lower percentages of packaging waste, such as glass cans and plastic. The characterisation done by Stellenbosch Municipality did not factor in inorganic matter, as this is not typically what one would find in a black refuse bag. It is unclear from the figures portrayed by Millard (2003 in Engledow, 2005) whether the waste category percentages measure mass or volume. However, Engledow (2005) states that based on these figures it is evident that waste generated in low-income informal settlements is composed of mainly inorganic and organic material. This is comparable to international data of waste composition between affluent areas and lower-income areas (Engledow, 2005).

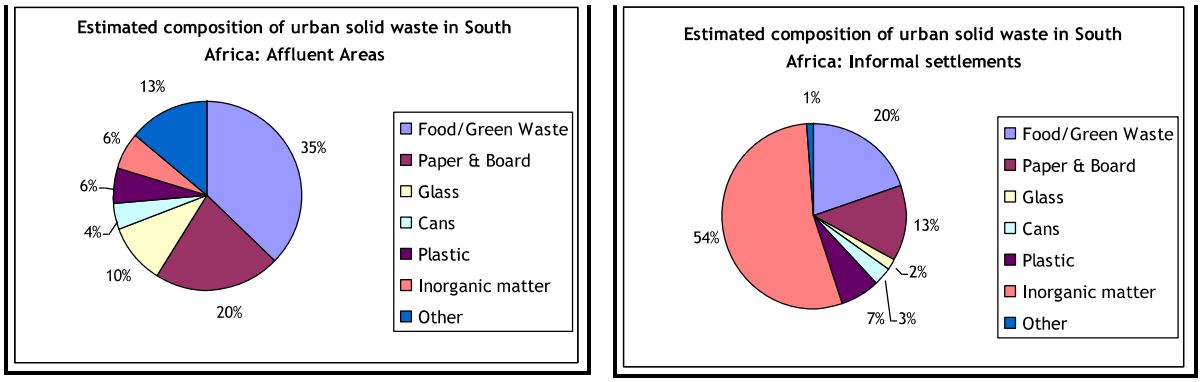


Figure 4.12 Waste generated in affluent communities and informal settlements in an urban area.

Source: Engledow (2005:47, compiled from Millard, 2003)

Haider, who is an expert in waste management and has a vast amount of life-world experience in this field, also confirmed that low-income areas tend to have a higher food waste percentage relative to other waste streams, particularly packaging waste, produced in the same community (Haider, 2012). The reasons for this were not examined in this study.

Food waste is a problematic waste stream as it can putrefy, create bad odours, attract pests and contaminate areas and water run-off. The systems knowledge that food waste makes up a relatively large percentage of waste in Enkanini enabled the focus to narrow down from general solid waste to a particular category of waste, namely food waste..

4.2.3 Exploring alternative waste systems

Thus far, the findings of the first two preliminary questions, the status quo of the current waste management system and what kind of waste is being produced in Enkanini, have been covered. The third part to systems knowledge that was established in this phase covers some alternative waste management options that were investigated through desktop research, field visits and interviews with representatives of each operation, which the co-researchers were part of. The reason for investigating these alternatives was twofold. Firstly, these alternatives form part of systems knowledge as the broader setting for waste management systems in low-income areas or informal settlements. Secondly, the field visits and interviews were used as a practical learning experience for the co-researchers and I, in which experiential learning[22] could be simulated by seeing operations in action and talking to people involved, rather than a theoretical learning experience of only reading and talking about these alternatives. Instead of an analysis of whether these options would have worked in Enkanini, only the advantages and disadvantages of each option will be listed under the respective headings of each option, starting in the next section. A theoretical evaluation of these two options as alternative interventions would not fall under systems knowledge, nor does such an analysis fall in the scope of a TD study, in which practical interventions follow theoretical explorations. Further research could be done on this in another study.

Due to time constraints, as well as developments in the life-world, only two alternatives were investigated in this manner, namely Tedcor (Pty) Ltd and TrashBack's systems. Field trips to other events, such as the Greyton Trash To Treasure Festival, are not seen as relevant possible alternatives, although they were very important as a boundary object and in the process of creating a learning environment and building relationships.

The three preliminary questions are being answered in a linear fashion, firstly by looking at the problems of the current system, then by looking at waste categories and finally by looking at alternative waste management systems. However, although the waste characterisation study took place after the status quo had been established, the explorations into alternative waste management systems were spread over several months and took place since before the characterisation study and right up until an alternative waste management system was implemented and piloted in Enkanini in Phase 3.

[22] As mentioned in Chapter 2, experiential learning was a very important part of the process to integrate knowledge and build relationships.

4.2.3.1 Tedcor (Pty) Ltd

The first alternative to the current system that was explored with the co-researchers was the company Tedcor (Pty) Ltd's waste management system. The following is a description of Tedcor's model and what benefits and shortcomings it has, all of which were determined through observations during field trips (Figure 4.13) and during interviews with Tedcor employees as well as independent actors who had been involved with Tedcor in a third-party capacity. This information was supplemented with desktop research.

Figure 4.13 The Tedcor waste collection team that we interviewed during a field trip to Johannesburg (photograph taken by author, 2012).

Tedcor is a private company that performs waste collections in mostly low-income areas, using a very specific business model that has been described as one of the purest forms of broad-based black economic empowerment (BBBEE)[23] in South Africa (Goldman, 2010). The company has been in operation since 1996 (Goldman, 2010). It is currently operating in six municipalities around the country and has recently expanded to the Ivory Coast as well (Houghton, 2012).

The company initially started out in the Western Cape as what was known as the Billy Hattingh Scheme, which provided cleaning services to Khayelitsha, the province's largest

[23] BBBEE is a South African policy that aims to realise the country's full economic potential while helping to bring the black majority into the economic mainstream, as well as a moral initiative to redress the oppression of the black majority and thus their exclusion from the formal economy during Apartheid

township (Theron & Visser, 2010). The scheme saved the City of Cape Town a substantial amount of money, bringing down costs to clean up Khayelitsha from R11 million per annum to R4.7 million per annum (Qotole & Xali, 2010). Despite these significant savings, as well as jobs created through this scheme, it was eventually abandoned due to strong controversies amongst, and eventual resistance from, the South African Municipal Workers Union (SAMWU), which feared for the job security of their members (Theron & Visser, 2010). The scheme was initially planned to continue as a franchise in other parts of South Africa, but when this failed to take off, John Houghton, a successful businessman who was to become Tedcor's CEO and consequently Chairman, then purchased the business and established what is now known as Tedcor, taking over the initial model but expanding and improving upon it.

Tedcor offers a community waste collection service that is more affordable than an in-sourced solution. Furthermore, it is more effective than what other providers can offer and reinvests approximately 80% of its revenues in the community (Goldman, 2010). The critical actors to make this possible, are the local government municipalities, the community contractors (CCs), the banks and the vehicle manufacturing company, MAN Truck & Bus (S.A.) (Pty) Ltd.

Their business model works as follows: Tedcor applies for a tender put out by a municipality to do waste collections in a low-income community. Upon being awarded the tender, Tedcor applies for a loan at the bank, purchases waste trucks in bulk from MAN and then contracts workers from the same community in which they will be performing waste collections. The bank is willing to supply the loan as it is seen as low-risk. MAN, an international leading commercial vehicle manufacturer, supplies waste trucks at bulk discount prices and is very willing to sell trucks to a BBBEE-rated company. The workers contracted from the community, or CCs, are trained as truck drivers and team leaders, going through rigorous training in accredited courses at the University of South Africa, such as bookkeeping, first aid and leadership skills (Houghton, 2012). The criteria to become a CC are, amongst others, a code C driver's license, in order to drive the waste collection trucks, good spoken and written English, and a Matric certificate.

Once the CCs have been selected by Tedcor, they are each given a waste truck and are encouraged to source a further ten to 14 people from the community, who the CC employs as part of his/her waste collection team. The CC is the truck driver and (s)he has six to 10 men working as truck loaders who jump off the truck to collect wheelie bins and black bags. Also forming part of the team, are between three and five waste pickers, usually women, who will

pick loose waste and collect it in black bags in the area that their team is working in. Tedcor, who is paid by the municipality, pays the CC. The CC is then responsible to pay salaries to the truck loaders and waste pickers in his team. In this way, Tedcor tries to simulate small enterprises, each run and managed by a CC and his waste collection team.

Essentially, Tedcor acts as a mentor to the CCs, and support them in running their own waste collection enterprises as entrepreneurs (Houghton, 2012). Tedcor assists with bookkeeping and other managerial issues when they crop up, including human resource issues. However, the overall objective is to let the CCs run their own waste collection enterprises as independently as possible, transferring skills to them that they can use in future. This concept is unique, as Tedcor sets out from the start with the objective to train employees in such a way that, should their contract end with Tedcor, they would technically have all the skills required to start up their own business, to a point where they could go into competition against Tedcor in the same industry. This has happened at least once before in Cape Town, when a former CC started up her own waste collection business after her contract with Tedcor ended, and she has grown her business to the point where she has now become Tedcor's primary competitor in tendering for waste collection services in Khayelitsha (Barnard, 2012). In Gauteng, Tedcor even went as far as registering the waste collection trucks in the CC's name, meaning that the CC owns the truck right from the start of their contract with Tedcor. Therefore, they do not only leave Tedcor having gained entrepreneurial skills but also owning capital (Houghton, 2012). This set-up has changed slightly, and in 2010 Tedcor amended this policy. Instead, Tedcor sets aside money each month for the CC during their contractual period, and at the end of the contract the CC can decide whether (s)he would like to keep the waste truck or rather take the money that was set aside for him/her.

Tedcor's business model falls under what is classified as an 'inclusive markets model' (Goldman, 2010). There are two types of business models that focus on the low-income market segment: The first is the 'bottom of the pyramid' approach, such as what Unilever and Procter & Gamble follow. These companies are inclusive of the poor in the demand side of operations, meaning that they sell products affordably and ethically to poorer consumers. The second is the inclusive market approach (Goldman, 2010), which is followed by Tedcor. This company is inclusive of its business approach in that it focuses on the low-income sector on the supply and demand side. Tedcor employs people in the low-income sector to render services to the low-income sector.

What makes Tedcor's business model so unique is that they have spun a web with various different partners and stakeholders, and placed themselves at the centre of this web (Goldman, 2012). In a sense, one could compare them to the puppet masters who pull various strings within various institutions to enable certain partnerships that would not have been possible without Tedcor as the intermediary. For example, the community contractor would not be able to get a loan from a bank to help him start up his business, because he would be classified as high risk. However, with Tedcor as the intermediary, the bank is given assurance that the money will be paid back, and thus the loan is granted. The model is cleverly engineered in that all partners benefit from doing business with Tedcor, either by making a profit or by saving money. For example, the municipality saves money by contracting Tedcor, who is able to provide collection services at a much cheaper rate than they themselves can, the banks make money when they give out loans to Tedcor as there is a guaranteed income over the contractual period, MAN makes money because Tedcor buys trucks in bulk, and they get accreditation and points for selling their trucks to a BBBEE-rated company, the community benefits through the jobs that are created for CCs, truck loaders and waste pickers and, lastly, Tedcor reinvests 80–85% of the money back in the community in various ways instead of giving more money back to its shareholders, thus benefitting the community as well as the municipality.

This type of model takes considerable effort to set up compared to other more straightforward business models, and as Houghton (2012), the chairman of Tedcor, said in an interview, "there are definitely easier ways to make money, and business models that ensure higher profit margins". However, Houghton, who has been with Tedcor from its beginnings and directed the company for many years, has a strong social conscience and his value and belief system influenced how the business model was set up and still operates (Goldman, 2012).

There are two possible future scenarios for this model, predicted by Houghton (2012). Either, more municipalities in South Africa become competent enough in governing their districts and consequently increasing business opportunities for Tedcor. Or, the unions become stronger in the public sector and dominate all public sector contracts, which would be highly disadvantageous to Tedcor and reduce their business opportunities severely. This model, therefore, has both advantages and disadvantages.

a) The advantages of Tedcor's model:

The way that Tedcor has managed to set up its operations has positive implications for all stakeholders involved. Their model ensures that the community benefits from regular, efficient waste removal services during Tedcor's three to five year contractual period with the local municipality. Further, it creates enterprise opportunities for local residents that have long-lasting benefits, because skills are transferred and an opportunity to acquire capital is made possible.

Tedcor has an excellent reputation in delivering reliable and efficient waste collection services that residents are satisfied with, as several interviews with residents showed (Reggia, 2012; Mpela, 2012). Residents often know the waste collection team personally as they are from their neighbourhood, and this personal connection to a service delivery entity not only means that residents can easily find out why their waste was not collected, but also makes it easier for residents to hold the collections team accountable (Houghton, 2012).

Tedcor is able to offer waste collection at a much cheaper rate than what the municipality can insource the service for. Tedcor is able to provide the service at around R26 per household per month whereas most municipalities offer the service at a cost of more than R80 per household per month (Haider & Nemukula, 2012). Even though wage rates for private contractor workers are generally lower than that of the municipality, the wage rates of Tedcor employees do match that of the City of Cape Town's with the CC earning about R7000 a month, the truck loaders earning about R1900 a month and the waste pickers about R1700 a month. The difference in costs of delivering the same service partly shows that waste collection does perhaps not fall within the core competencies of a municipality. Haider (2012) admits that, in his personal opinion, municipalities should not physically deliver the service themselves but rather make sure that the most competent provider delivers the service in the best possible manner. Similarly, Theron and Visser (2010) argue that often municipalities lack capacity to perform the job to its specifications.

b) The disadvantages of Tedcor's model:

Tedcor has to work with viable municipalities, which are well run, competent and have enough money to source out their waste services in order to operate its business. Of the 283 local governments in South Africa, there are only about 40 that meet this criterion (Houghton, 2012). Further, some municipalities are heavily influenced and controlled by SAMWU depending on how active SAMWU is in the region, which does not allow Tedcor to compete due to the fear of job losses for municipal workers (Houghton, 2012).

The biggest risk in Tedcor's model is the state of the local government, specifically regarding bribery and corruption (Goldman, 2012). Tedcor claims that it has never engaged in bribery to get a contract (Houghton, 2012; Glick, 2012; Barnard, 2012). However, as Professor Goldman (2012) indicated, it is his personal experience that the general South African public believes that a private company in the waste sector and especially in the Gauteng province, would likely not be able to get a contract without a bribe offer. This highlights the difficult environment a culture of bribery creates for businesses that adhere to a strict ethical and moral code of conduct. If corruption at the local and national government level becomes even worse, it certainly does not bode well for companies such as Tedcor.

Tedcor has not found a viable way to incorporate waste separation into its model so that recycling and composting would be possible. Trends show that recycling is becoming increasingly important in South Africa (Department of Environmental Affairs and Tourism, [n.d.]), as statistics show the decreasing landfill space and therefore the importance of diverting recyclables and the substantial amounts of food waste produced in South Africa (Nahman *et al.*, 2012). However, Tedcor's current recycling efforts, mainly undertaken at an MRF in Gauteng, have not proven successful in terms of the amount of recyclables collected. Profit margins in recycling are very small (Glick, 2012), so one needs to recycle large volumes for the financial model to make sense, and Tedcor has found that the amount of recyclables generated in their target areas is simply insufficient. Also, the logistics of collecting waste that has been separated at source, and processing it accordingly, currently does not make business sense for Tedcor to incorporate it.

Like all businesses run with a strong sense of social responsibility, much of the success of Tedcor in terms of a business that is able to make a profit through socially responsible operations that contribute positively to all parties involved, rests on the values and belief system of the person that was the driving force behind the business; in this case Houghton. The impact that a person's values and code of ethics has on a business is not to be underestimated, particularly in the managerial capacity (Goldman, 2012). At the time of interviewing Tedcor's employees (March 2013 – June 2013) they were undergoing a change in leadership, and Houghton (current chairman) was soon to retire and hand over leadership to the next generation of managerial staff. Houghton's belief system has had a major impact on how the company is run. This is a characteristic that is frail and can easily change with a change in leadership. Tedcor, therefore, faces the risk that new leadership will not have the

same belief system and the effort and strong belief it took for profits to be reinvested in the community instead of being paid out to shareholders, can be changed easily.

Lastly, to make business sense, one CC is allocated 6500 households to cover in a weekly waste collection route and (s)he will cover 3000 to 4000 kilometres a week (Goldman, 2012). Therefore, communities need to be of a certain size, or several communities in close enough proximity, for Tedcor to consider tendering for the waste removal service (Nemukula, 2012). Smaller communities will not fit the criteria and thus not be considered. Thus, Enkanini, one of many smaller informal settlements in South Africa, would not benefit from this service.

4.2.3.2 TrashBack

TrashBack is a social enterprise started in 2011 by three University of Cape Town graduates as a recycling initiative in the informal settlement Imizamo Yetu (IY) in Hout Bay, Cape Town. It operates as an incentivised recycling programme with the objective to turn apathy into action by altering the perception of waste (TrashBack, [n.d.]). Their separation (or sorting) facility is run as a co-operative (co-op), and members sort recyclable material into the respective categories of glass, tin, paper, plastic and so forth. Once sorted, the material is sold to respective recycling companies that come and collect the material regularly. Profits made are split amongst co-op members.

TrashBack set up operations in Hout Bay, after an ideal opportunity presented itself: The local government was already running a separation and composting facility aimed at the middle and high-income residents of Hout Bay, but not at the low-income residents. This existing facility was ideally located for TrashBack, at the foot of, and within walking distance of IY (McNaught, 2012). McNaught and his two partners used this set-up to extend the recycling initiative into the informal settlement of IY (McNaught, 2012). IY, like Enkanini, faces challenges with waste management and McNaught saw an opportunity for IY residents to benefit from a recycling initiative while simultaneously shifting perceptions to show that waste has a useful purpose. Through implementing an incentive scheme, McNaught and his partners hope to change attitudes towards waste by making people aware that waste actually has some value. IY residents can drop off recycling material at the sorting facility, where the value of the recyclables is equated in points and recorded under their name. At the end of the month points are added up and can be exchanged for vouchers or clothing. Recyclables have very little monetary value if dealt with in such small volumes, and therefore points for participants are subsidised to a certain extent and incentives are mainly sourced from donations by local businesses, such as the Spar or the local fish and chips shop.

The initiative has been received with positive feedback and much enthusiasm from IY residents, especially from children, who enjoy the concept of being able to swop recyclables for fun items such as pencils, toys or clothes (McNaught, 2012). Since launching the programme, TrashBack has collected 37 032 kilograms of recyclables through 590 registered participants, and has handed out R25 238 in rewards. TrashBack has also been recognised by the Western Cape Government as a 100% Green[24] flagship programme.

a) Advantages of TrashBack:

This model rewards participants for dropping off waste material that would have otherwise ended up in a landfill, thus providing an incentive to change behavioural patterns and possibly even shift perceptions that there are benefits in waste. By focusing on children, TrashBack hopes to instil a behavioural shift from a young age. They have noticed how children are able to bring about a change in their own households more effectively than older members of that household (McNaught, 2012).

TrashBack provides an opportunity for IY residents to partake in recycling at their own convenience, as the drop-off facility is within walking distance and TrashBack organises the logistics behind moving recyclables from the sorting facility to the respective recyclers. Thus, TrashBack has not only found a way to include the poor in the recycling drive that was already taking place in Hout Bay, but they have also managed to draw the interest of this specific segment of the Hout Bay community by providing incentives.

The model that TrashBack is working towards is closing the economic loop in that incentives are sourced from within the community. For example, TrashBack wants to stimulate the local economy of IY by working with local Spaza shop owners in IY and set up a system where points earned through TrashBack can be spent at the Spaza shop, thus widening the beneficiary circle.

Setting up a programme such as TrashBack's can be implemented independently from municipal capacity and ability, unlike Tedcor, which needs to go through formal tendering procedures to operate in an area.

b) Disadvantages of TrashBack:

[24] The 110% Green Campaign is an initiative started by the Western Cape Government to recognize programmes that contribute towards the government's effort to make the province the green economy hub of South Africa (Western Cape Government, 2012)

TrashBack only concentrates on recyclable material and has not found a way to incorporate composting into their model (McNaught, 2012). Although recycling is an important component of sustainable waste management, food waste, as seen from the characterisation results, is a big contributor to the waste problems of an informal settlement. Therefore, TrashBack's model could not have a significant enough impact on the problems created by waste in an informal settlement. The model is more useful as an awareness and educational tool to change perceptions of waste, rather than a solution to the waste problems of a settlement.

Focusing on recyclables means working with very small profit margins, which means that very large volumes are needed for TrashBack to operate as a financially independent enterprise without donations or subsidies, making the success of this model dependant on external financing.

The set-up of TrashBack in Hout Bay is ideal and contributed to the participation rate of IY residents, as the drop-off and sorting facility was already established and happened to be right next to IY, within convenient walking distance for participants. The existing infrastructure means that the facility is also easily accessible to trucks, which need to collect the sorted recyclables regularly, while TrashBack itself does not incur any costs in using this facility, such as rent.

Therefore, this set-up could be difficult to replicate in other settlements, as it is dependent on a drop-off and sorting facility close enough to the informal settlement accessible to large trucks and cost nothing, or very little, to use.

4.3 Moving from systems knowledge to target knowledge (Phase 2)

This section explains the process of moving from systems knowledge to target knowledge and what this target knowledge consisted of. The section correlates with the column entitled "Target knowledge" in Table 4.1 above, and will therefore be labelled accordingly from 1b) to 5b).

Target knowledge can be equated to the objectives of the intervention undertaken in Phase 3. Theoretically, target knowledge is the outcome of Phase 2 (Pohl & Hirsch Hadorn, 2007), but. as was already explained in Chapter 2, Phase 2 proceeded differently in practical terms and therefore there is no claiming that target knowledge was purely the outcome of Phase 2 but rather that target knowledge was achieved through actions that were part of both Phase 1 and Phase 2.

The way in which target knowledge was established was through the collaboration mode called 'integration by leader', which was explained in Chapter 2. This means that individual stakeholders through certain actions and events attained target knowledge and this resulted in the implementation of the pilot project in Phase 3. Once again, the importance of distinguishing between establishing target knowledge and integrating target knowledge is pointed out here. Phase 1 and Phase 2 did not achieve the *integration* of target knowledge, but rather the *establishment* of target knowledge. The outcome of establishing target knowledge was the implementation of a pilot project in Phase 3. The pilot project itself could be described as establishing transformation knowledge to a certain degree, but Phase 3 was when the actual integration of target knowledge amongst all stakeholders took place. This will be discussed further in Section 4.4.

There were pockets of target knowledge present at different stages of the research process and, as the next few sections will show, it was not necessary to integrate target knowledge before moving on to Phase 3, as long as target knowledge existed amongst the key drivers of the process. In this regard, the study differed from the theoretical ideal model of a TD study, and the difference lies mainly in that experiential learning was a key integration tool and therefore the implementation was needed to fully integrate target knowledge. For Haider, as the manager of the solid waste department at the municipality, it was the waste characterisation results and connection with Probiokashi (Pty) Ltd that led him to think in a target knowledge paradigm, i.e. knowledge related to "the need for change, desired goals and better practices" (Pohl & Hirsch Hadorn, 2007:36). For the co-researchers it was the field trips to see alternative waste management options in action, as well as the experience of using bokashi, that established target knowledge. For the larger group of households who participated in the pilot, it was the pilot project itself that led to acquiring target knowledge, which was indicated in interviews and through the continued use of bokashi by a percentage of participants.

1b) A low-tech intervention that addresses current issues

Systems knowledge, as described under point 1a) in Section 4.2.1, revealed that there are many problems with the current waste management system in Enkanini from the residents' perspective. Due to the inconvenience of the current system, an objective for the intervention was ensuring convenience for the residents and providing technology that is easy to use, i.e. a low-tech solution. Simultaneously, the intervention would have to address as many of the problems of the current waste management system as possible. Convenience and ease of use

were important pieces of target knowledge as the convenience factor assisted in desired behavioural modifications, as was determined in a study by Reis and Vincinte (2008) that researched influencing factors of participation in recycling programmes.

2b) Regular waste removal

After obtaining the waste characterisation results, which were discussed in Section 4.2.2, Haider narrowed his focus to concentrate on alternative food waste management options. From the beginning of his contract with the municipality in early 2012 he was very eager to find solutions for the problems that the waste department was experiencing and that time, and was therefore very open to collaborate with me, as a researcher, to find alternatives for the waste management in Enkanini. The results of the characterisation study, which is described as a boundary object in Chapter 2, assisted in establishing target knowledge and consequently initiated a pursuit to find alternative options that would address problems created by the food waste.

Haider consequently made contact with Probiokashi (Pty) Ltd. Haider's reasoning for concentrating on food waste was that if food waste could largely, and ideally completely, be removed from the concrete bays through an alternative management method, an irregular waste removal service would have a lesser negative effect, as a large portion of problematic waste would be removed from its problem-causing environment. To fully understand this reasoning, it is necessary to point out that Haider (2012; 2013) has very little faith in the municipality's capacity to ever conduct regular waste removals in Enkanini, as he stated on several occasions in meetings and interviews. Furthermore, it is necessary to take into account the bureaucracy that municipal officials are bound by, making it difficult to simply outsource a service to a private company, which in Haider's opinion would be the only option for efficient waste removal for Enkanini. Not only are there many processes to go through before a tender can be put out, but SAMWU will often block the process as well, as can be seen from the problems Tedcor runs into. This also played a role in Haider's reasoning, as he saw little chance of opening up the service to tender in the near future.

3b) Beneficiated waste

An additional desired goal for the waste management system in Enkanini is an intervention that creates direct benefits for the community. The current system is an open system in which waste is taken to landfill and potential benefits are lost. However, by creating a closed system, benefits can be contained within the community (see Figure 4.20 and Figure 4.21). Target

knowledge consisted of creating a closed loop in which waste generated by households would be processed locally, within the community. Two possible alternative closed loop systems were discovered, as described in Section 4.4.1, in which benefits could be kept within the community.

4b) Independence of municipal collection system

According to Haider, the solid waste department of Stellenbosch Municipality is undercapacitated in terms of financial resources and human resources, as was discussed under point 4a) in Section 4.2.1 above. Therefore, target knowledge consisted of an intervention that can run as independently from the municipal waste collection system as possible, while not draining limited financial resources. This objective or desired goal is addressed in Section 4.4.2, where the financial viability of the intervention and the degree of dependence the intervention had on the municipality are assessed.

5b) Reduced waste to landfill

Given the landfill constraints of Stellenbosch (see point 5a) discussed under Section 4.2.1, target knowledge consisted of an intervention that diverts waste from landfill. The potential landfill diversion of the intervention is discussed in Section 4.4.2.3.

4.3.1 Focusing on food waste

The previous section summarises the target knowledge that was established in Phase 2 of the research process. However, target knowledge was taken one step further in this phase; the intervention treatment method that would be implemented in Phase 3 was decided upon. As the results of the waste characterisation showed, food waste makes up a substantial amount of solid waste generated in Enkanini.

There are food waste processing methods other than the bokashi method that could have potentially been evaluated through pilot projects as alternative options for this study, and these were described in Chapter 2, Section 2.2.5. As already mentioned, retrospective desktop research on some of these alternative options helped determine theoretical advantages and disadvantages of each method and the conclusion is made that Bokashi worked extremely well in these particular circumstances.

4.4 Integrating target knowledge and establishing transformation knowledge (Phase 3)

Up to this point the preliminary questions as part of Phase 1 have been discussed, which established systems knowledge. Following that, the objectives of the pilot project were

discussed, which are equated to target knowledge and is categorised under Phase 2. Target knowledge was established as a result of systems knowledge integration, through actions such as field trips, a waste characterisation study and setting up boundary objects such as the use of bokashi, as was described in Chapter 3. As mentioned before, target knowledge had been established but had not been integrated at this point. The same is true for transformation knowledge that is usually established and integrated in Phase 3 of a TD study, and that is needed to transform existing practices into new, desired ones (Hoffmann-Riem *et al*., 2008). As this section will show, there are pockets of transformation knowledge that exist within the system at the conclusion of the research study, which were mainly brought about by the pilot project. However, transformation knowledge is far from fully integrated amongst all actors. Rather, the pilot project was the tool with which target knowledge was fully integrated by the end of the study, as will be explained in this section. The pockets of transformation knowledge that were established indicate an opportunity that a change process can take place if the process is driven and nurtured further. In other words, transformation knowledge is fully integrated amongst all stakeholders by transforming theoretical ideas and goals into tacit and explicit knowledge.

This section will cover actions that were part of Phase 3, specifically the implementation of the pilot project as a system on its own. Consequently, the findings of the sub-questions that were established at the beginning of the pilot project will be analysed and reflected upon.

4.4.1 The components of the intervention

This section describes the bokashi pilot project from a systems perspective. It will cover all the components that were crucial to the system to function, and thus it will indicate what is necessary to replicate such a system elsewhere, and what is needed to scale up the current operations to include a higher number of participants.

The stakeholders of this project were Stellenbosch Municipality, Probiokashi (Pty) Ltd, Enkanini residents, and I as facilitator and leader. In the capacity of researcher, facilitator and leader, I was a stakeholder in this process as I had an interest in setting up a transdisciplinary research study. To describe myself as a stakeholder departs from traditional research studies in which the researcher usually tries to play an objective role in the process.

Each stakeholder provided various types of capital in the form of knowledge, funding, infrastructure or labour. The intention of the intervention was to create a learning environment in which target knowledge could be integrated through action-oriented activities.

The system that was implemented incorporated 100 households, or participants. The number of households to include in the project was decided upon by the human and financial capacity, and infrastructure we had available to execute the project. 50 participants were selected through a randomly generated sample while the other 50 were self-selected through the co-researchers' help, as was explained in Chapter 3. The households were located throughout the settlement, as can be seen in Figure 4.14, although due to the selection process, some sections of Enkanini had more participants than others (Section E and F), while two sections had no participants at all (Section C and I) (please see Figure 3.9 for the different sections of Enkanini).

Figure 4.14 Satellite view of participants located within Enkanini (green pins), and the drop-off location (red pin) (Section B is not represented here as there was no map available from CORC to locate shacks).

Source: Google Earth. 2013. [Online] Available: http://www.google.com/earth/. GPS co-ordinates: 33°55'28.18"S, 18°50'41.57"E. [20/10/2013]

Each participant received two 25-litre buckets (see Figure 4.15). These two buckets were stacked inside each another and the inner bucket had small holes drilled into the base to allow for liquid created by the food waste to drain into the outer bucket. The liquid needs to be able

to drain in order not to drown the microorganisms that are sprinkled over the food waste as part of the bokashi substrate. Each of these units came outfitted with a lid that fit tightly onto the bucket in order to keep out as much oxygen as possible, allowing the anaerobic fermentation process to start. The households were asked to separate their food waste into these 25 litre buckets, each time sprinkling a handful of bokashi substrate over the waste and closing the lid again tightly once finished. Each bucket unit was numbered and correlated to the household that initially received this particular unit (Figure 4.16). In this way, the buckets could be tracked and it was easily measured how much food waste each household was generating.

Figure 4.15 The buckets used to collect food waste during the bokashi pilot project (photograph taken by author, 2012).

Figure 4.16 The numbers on the buckets were used to keep track of the buckets and to correlate it to the amount of food waste generated by each household (photograph taken by author, 2012).

The participants were then able to bring their buckets to the drop-off shack, namely the ERC, every Saturday between 9:00 and 12:00. It was left up to the discretion of the participant how full the bucket was when dropped. At the drop-off centre the bucket was weighed and the weight was recorded. The bucket was then emptied into one of several 220-litre drums that

were also tightly sealed to allow further anaerobic fermentation. Once empty, the buckets were washed and scrubbed clean to keep any potential smells and pathogens created by the food waste to a minimum. The participant then left with the same bucket and could also collect more bokashi substrate if the previous packet had run out. The food waste was stored in the 220-litre drums in the ERC until more drum space was needed, at which point the fermented food waste was processed using a sheet mulching/composting method, also known as lasagne composting, which entails layering alternative substrates of carbon- and nitrogen rich materials into the ground. This is then left to be composted naturally, and therefore doesn't require turning or further interference. The first 2.7 tonnes of food waste collected were processed locally, right outside the ERC, in five 750-litre wooden bins lined with plastic. Once filled up, a layer of soil was placed on top, and vegetable seedlings were planted directly into this soil in an effort to start a small food garden at the centre and to start producing food from the food waste. Once space at the ERC had run out, the remaining waste that was collected during the pilot project was transported to Kayamandi High School and Kayamandi Primary School to be composted there, as well as to AgriProtein to be processed by BSFL. The food waste was transported in the drums using a one-tonne pick-up truck.

Initially, when designing the pilot project with the co-researchers, the objective was to try and establish a closed-loop system, as depicted in Figure 4.17 and Figure 4.18. Two possible closed-loop systems are depicted and described here briefly. The first, depicted in Figure 4.20, is a manner of closing the loop that would produce a non-monetary benefit for participants in the form of vegetables. The compost created with the food waste would be used to grow vegetables, which in turn would be given to the participants when harvested. The food waste created through preparing and eating the vegetables would again be separated and fermented using bokashi substrate, which, once again, would be processed into compost, thus completing the cycle and closing the loop.

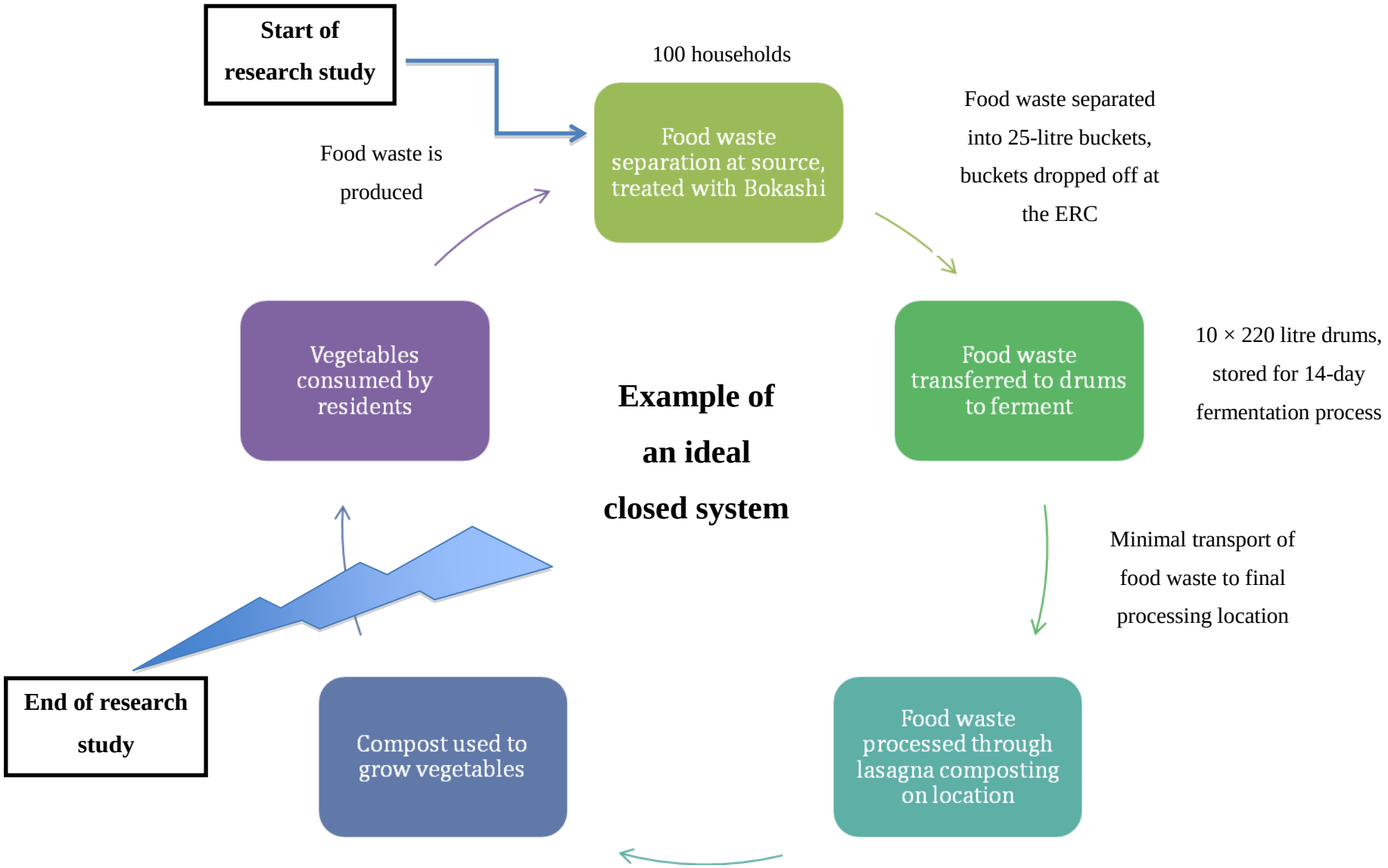


Figure 4.17 Ideal closed-loop system of growing food and recycling food waste.

Source: Author (2013)

However, due to limited capacity the project was unable to establish a closed-loop system, and the start and end of this research study are indicated in both Figure 4.17 and 4.18 respectively. The study ended at the point where vegetables were planted into the compost beds, but the vegetables were never harvested and given to participants. It was found that there was insufficient infrastructure and human capacity to follow through with the vegetable growing. One of the problems the project faced was a lack of water supply at the ERC to water the vegetables easily and regularly. The time demands of growing and producing vegetables was also underestimated and due to the time constraints of the project there was insufficient time allocated to this part of the project. A lack of space also meant that only a limited amount of seedlings were planted, which would not have been enough for all participants to benefit from.

A second way of possibly closing the loop, is through feeding the food waste to BSFL, which process the food waste into a soil enhancer, indicated in Figure 4.18 below. The soil enhancer does not have much value, but the BSFL can be harvested and sold as a protein substitute in animal feed, and can fetch up to R300 per kilogram according to Kotze (2012) from AgriProtein. The larvae can be ground up into a type of meal for domestic animals, or the larvae can be fed whole to chickens and other poultry. Once again, there was insufficient time to pursue this option and therefore the financial viability was not determined. We could not determine specifically whether enough revenue could be generated from the BSFL to cover expenses and have a profit left over to be distributed amongst participants in a cooperation model. The start and end of the study are indicated in the figure below.

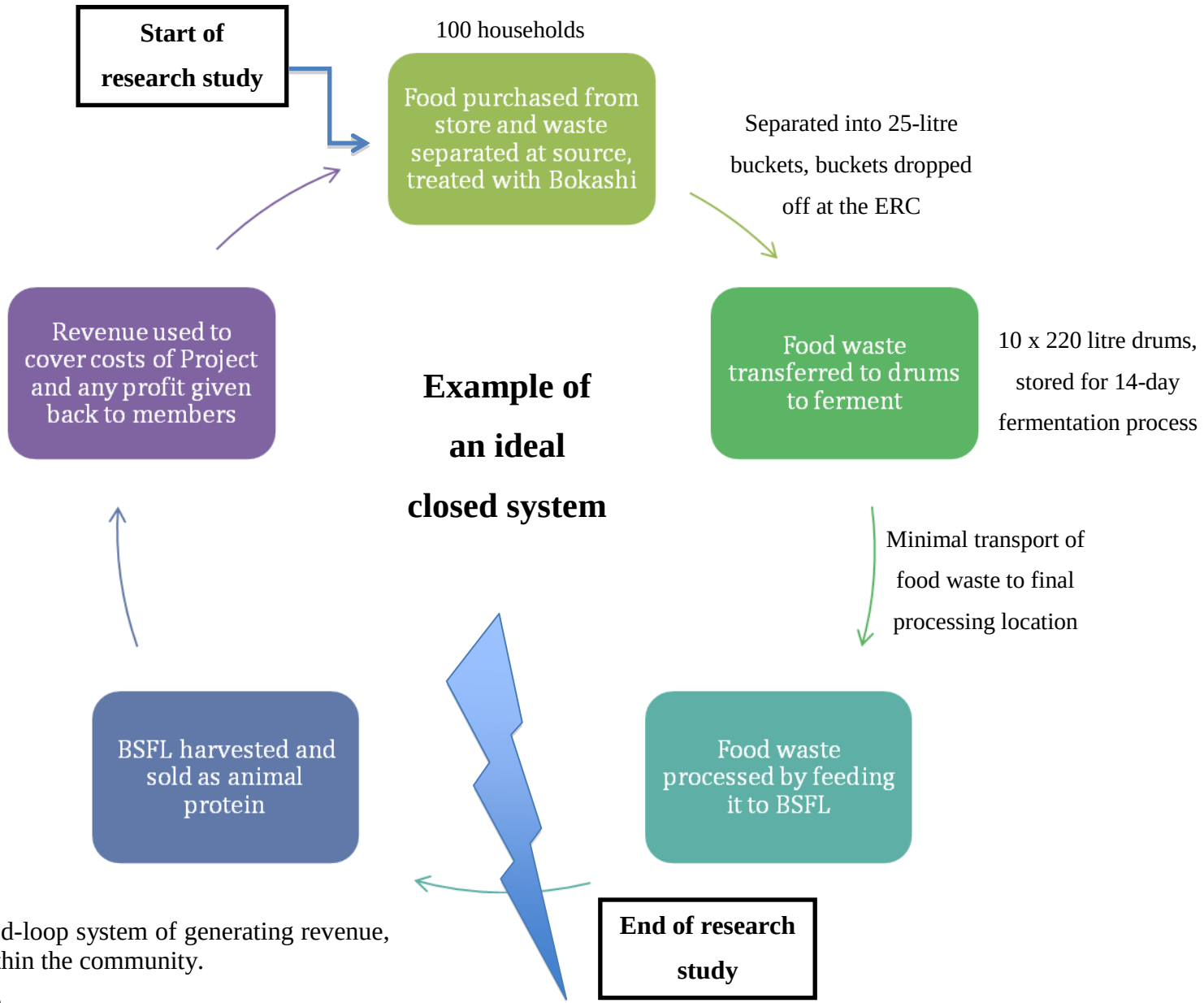


Figure 4.18 Ideal closed-loop system of generating revenue, which is reinvested within the community.

Source: Author (2013)

As such, the possibilities of establishing a closed loop system were not established and evaluated, and as can be seen from Figure 4.17 and Figure 4.18, the cut-off point was too soon as time did not allow for the logistics necessary to close the loop to be set up. In order to close the loop in the first option, a bigger space would have been necessary to plant vegetables, as well as readily available water to water these vegetables. For the second option, a bigger building or covered area would have been necessary in which the BSFL could process the food waste. Although this is an aerobic process, it still needs to be sheltered from the elements.

4.4.2 Findings based on the sub-questions of the pilot project

This section lists and discusses the findings based on the five sub-questions that were established for the pilot project.

4.4.2.1 What was the participation rate in the pilot project?

The findings showed that all 100 households that were included in the sample of the pilot project came to the ERC at least once during the nine-week period to drop off their food waste. The largest amount of waste that one household collected over nine weeks was 144 kilograms of food waste, and the smallest amount of food waste collected by one household was 6.5 kilograms over nine weeks. Factors that impacted the amount of food waste generated were the number of people living in the household and the amount of cooking done at home. For example, one household had only one member and in the nine-week period she was hardly ever at home due to staying with her boyfriend in Klapmuts[25] most of the time. Therefore, it took nine weeks to fill up the 25-litre bucket. In contrast, some participants came every week to drop of a full bucket of food waste, and some even came several times a week if they saw that someone was at the ERC.

There was no noticeable correlation between the distance participants had to walk to the ERC and the amount of waste they generated. However, there was a correlation between the distance participants had to walk to the ERC and the number of times they came to drop off their food waste. For example, participants who live in Section E, which is the same section in which the ERC was located, came three times more often to drop off their food waste than participants who live further away. Factors that influenced this were not only the convenience of living closer and therefore being more inclined to bring food waste buckets more often,

[25] Klapmuts is a residential area located 12 kilometres from Stellenbosch.

even if they were not completely full, but also living in visible distance to the ERC and therefore being able to see when there was any activity at the centre during the week and taking the opportunity to drop food waste then. This means that participants often took the opportunity to come and drop food waste during the week when there was activity at the ERC, which participants further away could not do as they could only be sure that we would be at the ERC between 9:00 and 12:00 on Saturday mornings.

There was also no noticeable correlation between self-selected participants and participants who had been randomly selected. Initially, when choosing the sample, it was assumed that the self-selected participants would exhibit a far higher participation and adoption rate than the randomly selected sample. However, percentage-wise, the randomly selected sample had equally positive feedback and adoption rate as the self-selected participants.

However, the final total sample of participants was made up of far more self-selected participants than randomly selected participants, which shows that self-selected participants were far more interested to participate in the project than randomly selected participants. This speaks to tacit knowledge and that residents with higher levels of tacit knowledge were more inclined to participate in the pilot project. Section 4.4.2.5 elaborates on this further under point 4.

4.4.2.2 What are the benefits and shortcomings of this particular waste treatment method from the perspective of Enkanini residents and the municipality?

In a survey that was administered at the end of the pilot project, participants were asked what they found most beneficial while participating in the project, as well as what criticisms they had. 90 surveys were administered and results show that 69% had no criticism toward the project. 18%, however, said that the ERC was too far away and thus made the walk difficult, while another 11% said the bucket was too heavy to carry and therefore inconvenient. (See Figure 4.19 for a visual representation of these criticisms.)

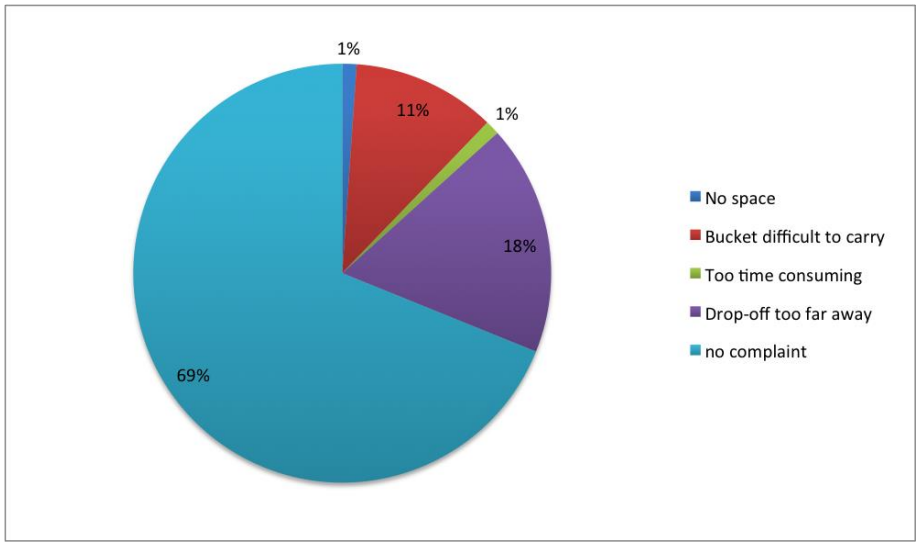


Figure 4.19 Critique from Enkanini households on the bokashi pilot project.

The benefits that were experienced by people were more varied. 32% said the biggest benefit in using bokashi was a reduced number of rats in and around their shacks. Another 29% claimed that the biggest benefit for them was the reduced bad odours around their shack, and a further 20% said they liked having a designated place for their food waste and knowing what to do with it. From interviews with Enkanini residents, it was found that many people try to flush their food waste down the toilet or it is thrown down the drains at the water taps because they feel it is better than leaving it lying around to start smelling and attracting rats. This, however, clogs drains and thus makes those toilets and taps unusable until the municipality sends workers out to unclog the drains. Thus, knowing what to do with their food waste to avoid these problems was the biggest benefit for 20% of the participants. See figure 4.20 for a visual representation of benefits experienced by participants.

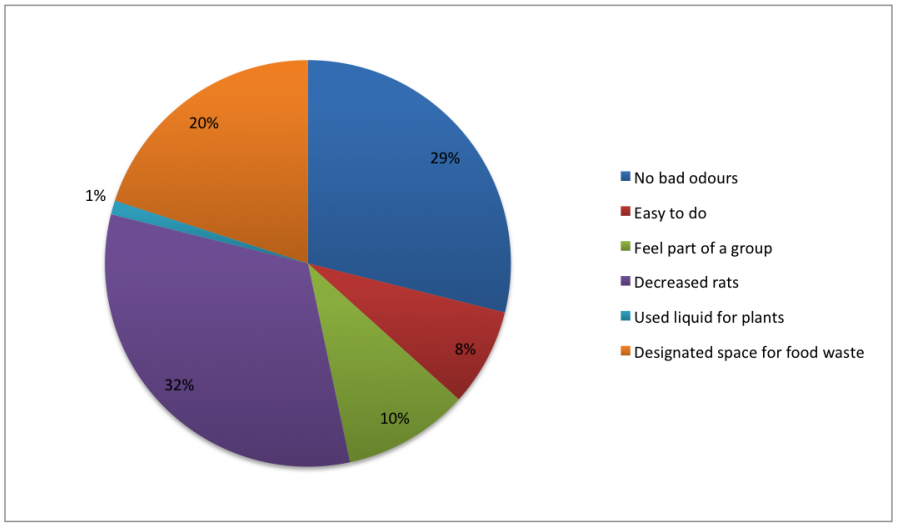


Figure 4.20 Benefits of using bokashi substrate during the pilot project, as experienced by Enkanini households.

The benefits as perceived from the municipality's perspective were determined through interviews with Haider. Amongst the benefits for the municipality, according to Haider, is a cleaner living environment for Enkanini residents and that this project was not dependent on municipal operational involvement, such as their waste collection service, to operate successfully. Haider sees this as a benefit, not only because the municipality struggles to find enough capacity to run its waste operations but also because Haider has little faith in the capabilities of the municipality and advises that if this project is to continue efficiently or to be scaled up, it should best be done without any of the operations relying on local government (Haider, 2013). Also, Haider was interested in the opportunities this project could present in the form of local economic development and beneficiating the waste in some manner, as demonstrated in the two proposed closed-loop models (Figure 4.17 and Figure 4.18). Haider expressed interest in pursuing such objectives further in another iteration of a pilot project in a meeting held with him in August 2013. Unfortunately, the diversion potential of this project is not sufficient to count as a benefit, as will be explained in more detail in the following section.

4.4.2.3 How much food waste can be diverted from landfill through the alternative processing method?

The data that was collected shows that on average an Enkanini household produces 4.9 kilograms of food waste per week. This means that over a nine week period 100 households produced 4 410 kilograms of food waste, which was diverted from landfill. That is an average

of 490 kilograms per week, resulting in about a 25.57 tonnes diversion potential per annum for 100 households.

If these numbers are to be scaled up, the diversion potential is as follows: There are 2 500 households in Enkanini, which means around 12 250 kilograms of food waste is produced per week, if the data collected during the bokashi pilot project is taken as an average for the whole settlement. That means there is a potential of diverting 639.17 tonnes of food waste per year[26] from the landfill if an alternative food waste management system were to be implemented in Enkanini. When these numbers were presented to Haider in a meeting in 2013, he stated that this is a very small amount in the overall picture, as 639.17 tonnes is less than what Stellenbosch landfills in waste per day. In 2012, over 550 000 tonnes were landfilled in Stellenbosch (see Figure 4.8), putting the daily average MSW landfilled at 1500 tonnes. That positions the food waste diversion potential from Enkanini alone at a mere 0.1% of the yearly total, hence having a very low impact.

Therefore, the significance of this project does not lie in the diversion potential, but rather in other success indicators, such as the social learning that took place (discussed in Section 4.4.2.5), partnerships that were forged and processes that were started in a recursive environment indicating the potential of a change process. The implications and significance of this project will be discussed further under question 5 in section 4.4.2.5.

4.4.2.4 What are the costs of the alternative processing method and are these feasible compared to current costs?

Municipal funding for the project officially stopped at the conclusion of the pilot project in December 2012. The project has continued for any participants who were interested in carrying on with it, enabled through three months' donations of bokashi substrate from Probiokashi (Pty) Ltd and through the research funds of Claire Mollatt, a fellow ISUG researcher who took over the bokashi project in April 2013. This is expanded upon under question 5 in section 4.4.2.5.

The municipality has verbally expressed support for the continuation of the project, ranging from the municipal manager, Christa Liebenberg, to André van Niekerk, the head of the Engineering Department, as well as from Saliem Haider, the head of the solid waste department. A positive interest was shown from various ward councillors as well, including Paul Biscombe and Pietman Retief. However, after several attempts to secure municipal

[26] 52.1775 weeks are taken to make up 1 year

funds from various sources in order to continue with the project after the nine-week pilot had concluded, Haider wrote in an email that he had been advised to use funds from the solid waste department's budget to allocate to the project (Haider, 2013). As the project was not originally included in the solid waste budget at the beginning of the financial year, Haider said he would need to try and move some funds around in his own department in order to make them accessible to the project (Haider, 2013). This has not been successful yet (August, 2013).

The total cost of the nine-week pilot project, including capital and operational expenditure, came to R65 770 for 100 participants (see Figure 4.21). This is broken down into capital costs of R14 573, operating costs of R31 447 and R19 750 for the two barbecue events that we organised as a motivational tool and as a thank you for participating. To continue this project on the same level as it had been running during the pilot project, with no difference in number of participants, infrastructure, wage rate and bokashi food waste processing methods, running cost would be R15 724 a month, a cost of R157.24 per household per month. This is, however, not an existing option as life-world circumstances have already changed, and if the project is to be operated on a full-time basis, wage rates will need to be adjusted and infrastructure will need to be upgraded. For example, the drop-off location that was used during the pilot project, namely the ERC, has been reconstructed and improved, and it is envisioned to become an office space, and a place for meetings, workshops and demonstrations for the use of all ISUG members. Thus, a new drop-off location will have to be sought. Currently, the households who are continuing with the bokashi method are dropping their food waste a few hundred metres away from the ERC, at another shack which is rented from the owner at R300 per month and paid for from Mollatt's research funding (more detail is given under question 5).

ENKANINI FOOD WASTE PILOT PROJECT					
ACTUAL COSTS					
Participants (households)				100	
Weeks				9	
Food waste recyled (kgs)				4 468	kg
Waste per participant / month (kg)				20	kg
CAPITAL COSTS	Qty	Price		Total Cost	
Buckets - 25ltr	200	R	33,00	R 6 600	
Drums 220ltr	7	R	139,00	R 973	
Collection site (shack)				R 7 000	
Total Capital Costs				**R 14 573**	
OPERATING COSTS	Qty	Price		Total Cost	
Bokashi 1kg bags	385	R	18,00	R 6 930	
Staff costs					
Full time helpers (monthly)	3	R	1 667,00	R 5 001	
Part time helpers (hourly)	75	R	20,00	R 1 500	
Project Manager (full time)	437	R	17,00	R 7 429	
				R 13 930	
Travel costs (km)	873	R	5,00	R 4 365	
Miscellaneous (plastic bins, gloves, soap, drinks, sponges, scale, brooms, spade, refuse bags, pens, clip boards, printing cots etc)				R 3 000	
Marketing					
SMS bulk service				R 700	
				R 700	
Depreciation				R 2 522	
TOTAL OPERATING COSTS - excluding Braai costs				**R 31 447**	
Cost for 5 months				**R 78 618**	
Braai 1 - beginning of project	100	R	40,00	R 4 000	
Braai 2 - end of project	350	R	45,00	R 15 750	
				R 19 750	

Figure 4.21 Costs of the Enkanini bokashi pilot project**.**

Source: Burns (2012)

A crude estimation of operating costs for 2 500 households is R95 000 per month. This would include bokashi substrate at R18 per kilogram, transport and running costs of a vehicle, wages for the unskilled labour of ten people, rental costs of multiple drop-off locations within

Enkanini and the salary of a project manager. This estimation does not take into account start-up costs. In terms of cost per tonne of food waste, this estimate would amount to R1784.04 per tonne at 639 tonnes of food waste per annum. This rate is still relatively acceptable if compared to the estimate cost of the current system that is not even an effective waste removal system.

The current system is estimated to cost R2.9 million per annum in terms of labour and cleaning of vehicles, as De Wit's 2013 report states. It is not clear if the category termed "cleaning of vehicles" is also inclusive of fuel, maintenance and depreciation costs. However, if one assumes that a household produces one black bag of general MSW per week, and one black bag weighs on average 8.7 kilograms[27], then the 2 500 households living in Enkanini generate around 1 135 tonnes of MSW per annum. This means that the cost of the current system of R2.9 million per annum works out to R2 555 per tonne of MSW. This is compared to R1 939 per tonne for the bokashi project and R4 494 for bokashi cost per tonne plus the cost of residual waste collection (see Figure 4.22).

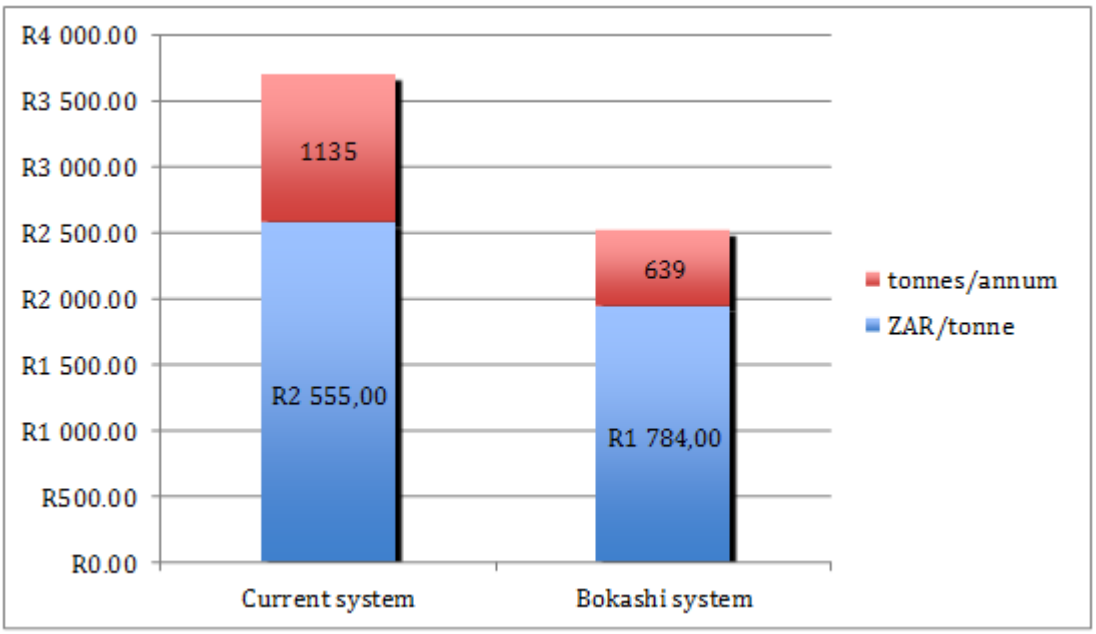


Figure 4.22 Comparison of cost (in blue) and respective waste tonnes/annum diverted between the overall waste management system and the bokashi method (for 2 500 households).

[27] This weight average was calculated from the average weight of a black bag that was collected in Enkanini for the waste characterisation study.

The estimate of MSW, or household waste, generated in Enkanini, which can be seen in Figure 4.5, is relatively high compared to what Nahman *et al.* (2012) found in their study about the costs of household waste in South Africa. According to the authors, the low-income sector generates on average 0.41 kilograms of MSW per person per day. This equates to about 150 kilograms of MSW per person per annum. If these numbers are applied to Enkanini residents, Enkanini would generate 675 tonnes of MSW per annum, which is 450 tonnes a year less than the estimate worked out from the waste characterisation study. Hence, the cost of the current system would increase to R4 296 per tonne if these figures were taken as a base instead. The waste characterisation study took a very small sample from Enkanini, as has been explained before, and thus these figures may not be accurate. Therefore, this suggests that the real cost of the current waste management system in Enkanini lies somewhere between R2 555 and R4 296 per tonne of MSW.

Haider (2013) stated that the cost of R1 784 per tonne for the bokashi system is very similar to the cost of the current recycling programme that the municipality is running for Stellenbosch. When comparing these costs to the options that were evaluated in De Wit's study, they are much higher than even the worst possible alternative, which was transporting all MSW out to BSL at a cost of R66 528 per tonne (in 2013). Therefore, the cost of R1 784 per tonne is very expensive considering the minimal landfill diversion of 639 tonnes per year that this system can achieve from Enkanini.

However, the residents of Stellenbosch send around 54 000 tonnes of food waste to the landfill per annum, which is about 10% of the total MSW landfilled in 2012 (see Figure 4.8). This creates substantial diversion potential considering the landfill constraints and urgent need for diversion programmes. Due to time constraints, the cost of implementing the bokashi system in other wards of Stellenbosch was not assessed. Therefore, further research is needed to establish costs and compare these to different models and different food processing methods to determine which option would be economically sustainable. The figures above are only a very rough estimation of costs, but these costs can change, especially if further research is undertaken, to determine how a revenue stream can be established from the food waste collected through such a project, and to what percentage this revenue stream can cover the costs of the project.

[28] These costs do not include capital costs of acquiring waste transport vehicles, nor the costs of congestion, accidents, pollution and the impact on roads (De Wit, 2013)

4.4.2.5 Did social learning take place and does this have an impact on the broader context of Stellenbosch's waste system?

As already mentioned under question 3 and 4 in Sections 4.4.2.3 and 4.4.2.4, respectively, the significance of this project does not lie within the diversion potential, nor is the cost of the project such that it allows for an unconstrained roll-out to all households of Enkanini and of Stellenbosch. The significance of the project also does not lie within the technology itself, as the bokashi system has been in existence since the 1980s (Van der Merwe, 2012) and has been used successfully in many countries, mainly large parts of Asia, New Zealand and Australia, to treat and process food waste, in an attempt to move away from chemical use in agriculture and instead use EM as a soil fertiliser and enricher (Merfield, 2012). Thus, bokashi did not have to be tested for efficiency or effectiveness in treating and fermenting food waste.

Rather, the significance of this project lies in igniting a change process that was enabled through a recursive learning environment where partnerships, positive engagement and capacity building were facilitated and mediated in an unlikely setting. By adhering to the principles of TD research, namely reducing complexity, contextualising the study in the life-world, practicing open encounters and shaping the research processes in a recursive manner, a learning environment was created that increased tacit knowledge amongst participants and other actors. The outcomes of this study can be described as process indicators, as they signify the beginning of a change process. Change is, according to Hirsch Hadorn *et al*. (2008), manifested once transformation knowledge has been fully integrated amongst all stakeholders. A small aspect of change was visible in this study, when a number of participating households chose to continue with the bokashi method beyond the pilot project and are still continuing with the method at the time of writing this (September 2013). The change in behaviour indicates transformation knowledge has been integrated amongst these particular stakeholders, but as will be explained further under point (3) in this section, transformation knowledge was not integrated amongst all stakeholders in the study as real change to the waste system in Enkanini has not yet taken place. The process indicators were embodied by the positive engagement of the municipality in Enkanini: (1) the partnership established between a private company, a municipality, a university and Enkanini residents to assemble different expertise, (2) the integration of target knowledge amongst Enkanini residents, municipal officials and ward councillors, (3) the success of the technology specifically in the context of an informal settlement in terms of benefits experienced by participants and (4) the capacity built amongst co-researchers to engage in service delivery

issues, navigate and mediate relationships and run projects with increased confidence and increased technical know-how.

All these outcomes are embedded in a change process that, at the conclusion of this pilot study, is in its beginning stages. Although the outcomes that are positioned as process indicators signify potential change, they do not guarantee change. For lasting change to come about and transformation knowledge to be integrated in the shape of an improved waste management system for Enkanini that holds true to economic, social and environmental sustainability, this process would have to be driven and nurtured. In the following paragraphs each of the process indicators is covered, which relate to the question of social learning and the broader impact of this on Stellenbosch's waste system.

1) The positive engagement of Stellenbosch Municipality with Enkanini

One of the impacts of the research study was the positive engagement between Stellenbosch Municipality and some of Enkanini's households through the pilot project, although only 4% of the total Enkanini households were involved in the project. This was the first time that the municipality has had a positive engagement with Enkanini. This conclusion stems from observations, interviews and meetings with municipal officials, Enkanini residents, ward councillors and university professors. Enkanini has a reputation of aggression and antagonism toward the municipality, and is considered a politically volatile settlement as the ISUG experienced when they first started engaging in this context in 2011.[29] Thus, Enkanini is regarded as a problem area for the municipality [30] and the municipality has never implemented any initiatives in this settlement, other than providing the free basic services on a very limited basis, due to the tenuous relationship.

The pilot project was therefore the first municipal-funded initiative to run smoothly in Enkanini. There are various factors that could have influenced a smooth and peaceful implementation. The fact that waste is not a highly politicised service, like sanitation or electricity, contributed to this, as the project did not attract unwanted political attention. Also,

[29] When the ISUG was first established in early 2011 and researchers wanted to start engaging with Enkanini residents, it was advised by the municipality to refrain from entering the settlement during the time of the municipal elections as there were concerns over the safety of Enkanini for outsiders.

[30] This conclusion was a result of many conversations with municipal officials, as well as being part of meetings in which conversations were had around the difficulty the municipality was facing with Enkanini, and talking to third-party actors who have been privy to inaccessible information.

the municipality agreed to take an invisible role in the implementation of the project and thus suspicion that residents often feel towards any municipal representatives was avoided. Most pilot participants were unaware that the municipality was at all involved, and this is a positive indicator that the municipality is still able to implement initiatives in Enkanini with positive outcomes through indirect engagement procedures. Often a positive outcome in a problem area is used as a political and marketing tool to blow up the image of the dominant political party affiliated with the municipality. Although there were attempts by the municipality to make their involvement explicit at the barbecue events and by pushing the story into the limelight through their public relations office, the co-researchers advised against these strategies (Tyawa & Mthelo, 2012). The co-researchers were adamant that no municipal branding should be placed at the barbecue events, saying that this might spark antagonism towards the project amongst participants or be taken as an opportunity to complain about other services, such as electricity provision. Although the project received attention by a few councillors and municipal officials, and received one write-up in a local newspaper, it stayed a relatively quiet story in terms of media attention or politicians spinning it to their own advantage.

The barbecue events were the most powerful indicators that households had received the project positively. The first barbecue (Figure 4.23) was held five weeks into the project and 89 of 100 participants attended the event, while dropping their food waste off at the same time. The second barbecue event was larger and was held at the conclusion of the pilot project. All participants were invited to this event and each could bring two guests. 350 Enkanini residents came to that event and this was the first time that a larger group of Enkanini residents gathered peacefully in one location. The event took place just three weeks after the violent protests that occurred around electricity provision, and many people, including municipal officials, were nervous that the barbecue event was too soon after these riots and was therefore a risky affair. It was also difficult to find a venue for the barbeque due to this reason, but Kayamandi High School eventually agreed to rent out their hall for the occasion. The event turned out to be very festive and there were no incidents of aggression or violence. A few participants made speeches at the event in which they expressed their disappointment that the pilot had come to an end. The disappointment was so great for some that we asked participants who wanted to continue with the bokashi system to write down their names, so that options to continue could be sought and they could be contacted again. It was then agreed that Probiokashi (Pty) Ltd would donate the bokashi substrate during the

funding gap until the municipality had the capacity to implement a second phase or roll out the project to all residents. In this way, the participants who so wished could continue to recycle their food by means of the bokashi system and Mthelo, one of the co-researchers, agreed to continue working on drop-off days over the December holidays. Eight months later, in August 2013 there are still households continuing with the bokashi system, indicating the beginning of a change process. This will be discussed further under point 4.

Figure 4.23 A picture of the first barbecue event held at the drop-off centre five weeks into the project (photograph taken by author, 2012).

2) A partnership was established between a private company, a municipality, a university and Enkanini residents to assemble different expertise

During this study a partnership was established between three different institutions as well as Enkanini residents. This assembled different expertise and types of knowledge to capacitate the project. The municipality provided financial means, as well as waste management expertise through Haider. Probiokashi (Pty) Ltd provided technological expertise on EM and bokashi. The university provided an academic background in which this project could be situated and, as such, enabled an exploratory and experimental learning approach that suited

all actors by mitigating the risk of failure. The co-researchers in Enkanini provided a link into the community that opened up legitimate engagement opportunities and their experiential or tacit knowledge of everyday life in the settlement was an important contribution to the design and implementation of the pilot. This combination provided the capital necessary for the smooth implementation of a pilot with positive outcomes, as well as creating the potential for future partnerships.

3) The integration of target knowledge amongst Enkanini residents, municipal officials and ward councillors

Many actors expressed scepticism about the potential of this project before implementation, which primarily was manifested in doubt about the adoption rate amongst participants. Doubt was expressed by municipal officials, various ward councillors and university professors if residents in such a poor community would place any priority on sorting food waste and treating it with bokashi substrate, let alone dropping off the food waste, which would require time and effort (Haider, 2013; Biscombe, 2013; Retief, 2012; Brent, 2012).

The positive outcome of the pilot project in terms of participation from households surprised them, and the outcome of the pilot lead to the integration of target knowledge as it converted theoretical knowledge into tacit and explicit knowledge. For example, the ward councillor for Cloetesville in Stellenbosch, Councillor Biscombe, stated in a meeting that he was very sceptical at the beginning that Enkanini households would adopt the bokashi method, but after hearing the result of the pilot he expressed great interest in starting a bokashi programme in his own ward (Biscombe, 2013). This shows that he gained target knowledge as he expressed interest in change, a desired goal and a better practice amongst residents in his ward.

A similar case is that of municipal officials such as Haider and Liebenberg, who were also surprised by the participation and positive feedback households gave. This prompted Liebenberg to support the project in calling for the continuation thereof, and Haider is impelled to seek ways of continuing with the project, as was proved through numerous meetings in which we discussed possible ways forward for the project. This also signifies the integration of target knowledge that has taken place as Haider is expressing the need for change, a desired goal and better practices – not only for Enkanini residents but also for the whole town of Stellenbosch.

The indication that target knowledge was integrated amongst Enkanini residents was observed during the barbecue event at the end of the pilot when participants expressed the wish to continue with the bokashi programme, and consequently by observing the continuation of the programme by 60 residents. During the barbecue event in December 2012 a number of residents expressed disappointment that the project was at an end and that they had to go back to the old waste management system of throwing their food waste into the concrete bays. When it was explained that there was insufficient human, financial and infrastructure capacity available to carry on with the project, some residents made suggestions of how the project could continue. One of the suggestions was that the 200-litre drums could be left outside the drop-off shack so that they would be accessible to people at all times, thus eliminating the need for the co-researchers, me or any other labourers to be present on drop-off days to empty the buckets into the drums. Their wish to continue with the project initiated the donation of bokashi substrate by Probiokashi (Pty) Ltd in an effort to help people continue with the project without the financial support from the municipality.

Through bokashi donations and through co-researchers agreeing to carry on helping on drop-off days, the project was able to continue for those who wished to participate. Consequently, since the official conclusion of the pilot until the time of writing this (August 2013) there have been 60 residents continuing to use bokashi, and the co-researchers have taken on driving the project in terms of keeping up participation. For example, Tyawa has made use of a megaphone to call out to participants and send out the message that they can drop their food waste on Saturday mornings at the drop-off shack. Communication with participants regarding requests to drop off food waste used to be via SMS during the pilot project, but seeing as Tyawa did not have the means for that, he took the initiative to use a megaphone instead.

Mollatt, also stepped in in April 2013, as mentioned, to help with the logistics that required the use of a vehicle, phone or computer. Although the participation dropped from 100 households during the pilot project to 60, the continued practice of bokashi is an indication that target knowledge of desired goals, better practices and need for change in terms of a more effective waste management strategy, has been integrated amongst these residents. The fact that this project has continued with minimal financial and institutional support also indicates the beginning of a change process that needs to be nurtured and driven forward in order to bring about real and lasting change in terms of a more sustainable and effective food waste management system for Enkanini.

To summarise, the pilot project was important in constructing knowledge that enables behavioural change. Constructivist theory posits that learners create meaning for themselves from personal experiences, thus constructing knowledge rather than absorbing explicit knowledge (Darby, 2006). Constructing knowledge from everyday experiences is called tacit knowledge and is therefore subjective and affective in nature, and has been referred to in other chapters of this study as experiential knowledge. Taking action is therefore vital to construct tacit as well as explicit knowledge and as cognitive dissonance theory states, action that changes behaviour may also lead to a change in thinking and attitude to justify the new behaviour (Stern, 1992 cited in Darby, 2006). As a study done in an English village, recounted in Darby's (2006) article, shows, when tacit knowledge levels are low it is hard to engage people in initiatives, but action is needed to increase tacit knowledge creating a paradoxical scenario. This was observed during the pilot project when residents who were selected in the original sample did not want to participate in the project, leading to a shortfall of 40 participants to make up the quota of 100 (explained further in the following section). The quota was eventually filled with other residents who were self-selected to participate in the project and therefore must have had a higher level of tacit knowledge.

4) The success of the technology in the context of an informal settlement judged by the benefits experienced by participants

As was stated above, the technology itself did not need to be tested as it has been used successfully in many parts of the world since the 1980s. However, a significant outcome of this study was the success of this technology in the context of an informal settlement whose residents struggle with many aspects of daily life, such as extreme poverty, inadequate services in a challenging living environment, food security and nutrition, as well as health deficiencies and diseases. The survey administered to participants showed that benefits of bokashi far outweighed its weaknesses, and the weaknesses had more to do with the logistical design of the pilot project rather than with the technology itself, as can be seen in Figure 4.18. In interviews conducted in 2013 with participants who had chosen to continue with the bokashi programme, the benefits as stated in the survey results were once again reiterated (Pamana, 2013a; Pamana, 2013b; Zukiswa, 2013), such as reduced rats and a reliable service that processed food waste effectively.

Another sign that the technology was well received amongst residents, was the fact that some residents voluntarily joined up to participate in the pilot. The initial sample included 50 randomly selected residents and 50 residents who had expressed interest to the co-researchers

previously. The final sample of participants was constituted quite differently from this original plan in the following ways: Only 43% of the randomly selected sample residents eventually partook in the pilot. Of the residents selected through the co-researchers, 84% eventually participated. This meant that the quota of 100 participants was not filled through the original selection process. However, the remaining free buckets eventually were distributed to self-selected residents who had heard of the project through neighbours or friends or who saw the activity happening at the ERC and decided to find out what was happening. The final sample of participants was thus made up of 19% randomly selected participants, 42% selected by co-researchers, and 39% self-selected participants (Figure 4.24).

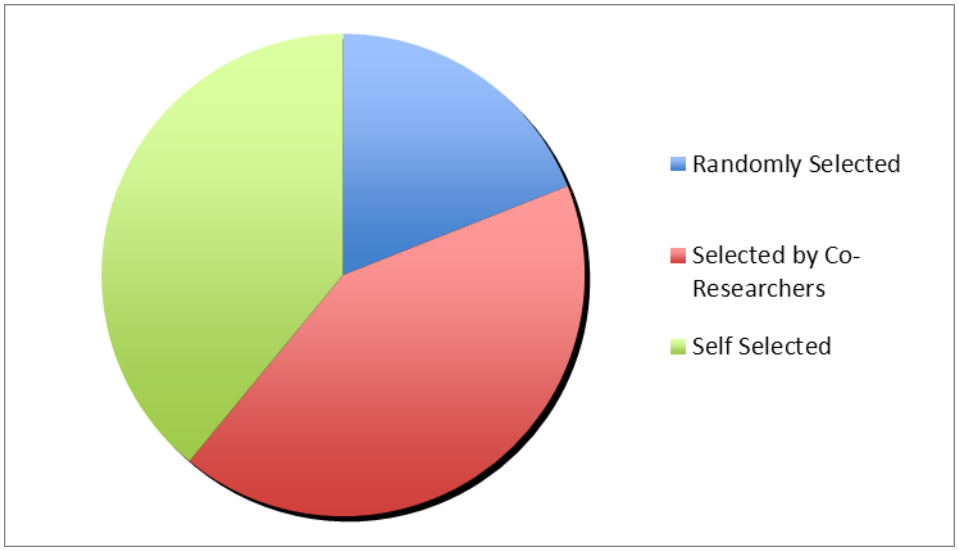


Figure 4.24 The final sample of participants categorised by selection method.

Furthermore, throughout the pilot project more residents enquired regularly on how they could join the project. Unfortunately, there was only capacity for 100 participants and new requests to join had to be turned down. However, the interested residents' names and phone numbers were recorded, and they could be included in case of a larger roll out of the project in the future. In one case, a resident decided to take matters into her own hands, and by using one of her own buckets she started to separate the food waste and asked her neighbour, a pilot participant, for some bokashi substrate to treat it with. She then dropped off her food waste at the ERC regularly. Although her food waste was accepted, the amount of food waste she dropped was not included in the data set.

The technology worked well for the co-researchers and I who handled the food waste regularly, as the bokashi eliminated the risk of contracting illnesses and diseases through

pathogens. It was also advantageous to work with bokashi-treated food waste, as the smell is not as unpleasant as non-treated food waste. This is due to the fermentation process that bokashi brings about, and therefore the food waste has a more yeasty smell to it. Lastly, the pilot was run without the need for heavy infrastructure, and solutions to all obstacles were found, such as running out of composting space at the ERC, but finding more space at Kayamandi High School and Primary School.

5) The capacity built amongst co-researchers to engage in service delivery issues, navigate and mediate relationships and run projects with increased confidence and increased technical know-how

One of the impacts of the study was an increased capacity to engage amongst co-researchers around project implementation and service delivery issues. In this way, the study had a direct and personal impact on the co-researchers. This was determined through interviews and informal conversations with the co-researchers and other ISUG members.

The ways in which this increased capacity to engage became visible was through actions of the co-researchers, for example the co-researchers continuing to drive the bokashi project on their own after the end of the pilot and after personal withdrawal from hands-on involvement in the project. Tyawa, who organised a megaphone, called participants to continue dropping their food waste, and all three co-researchers still continue to be at the drop-off shack every Saturday to receive food waste and clean buckets for those continuing with the project. Tyawa has also been called in by other ISUG researchers to mediate conflict that had sprung up between groups of residents who are part of the sanitation pilot project (Tavener-Smith, 2013). Additionally, Tyawa has attended councillor meetings in which the issues of the Stellenbosch waste management system were discussed and has expressed interest in continuing with the bokashi project on a larger scale. An increased capacity to engage was also visible in Mthelo, who went on to become the first hub operator for the iShack project[31] and often quoted his experience with the bokashi project during the interview for the hub operator position, as well as when asked for his input in his capacity as hub operator (Wessels, 2013).

[31] A hub operator was employed through the iShack project to manage installations of solar units, operate them and maintain them. Mthelo has been helping to set up the first 20 solar customers for the iShack project and has received in-depth technical training.

From observations and my personal experience of working with the co-researchers for a year, right from the beginning when the ISUG first met them, I have noticed a more relaxed and self-assured manner in their engagement as the project developed and a stronger relationship between us was established. Sileji, who joined a fieldtrip to Johannesburg to view Tedcor's operations, said in an interview that she enjoys being associated with the ISUG and seeing how the community benefits from the various projects that have been undertaken by the group. It is important for her that she and the two other co-researchers, Mthelo and Tyawa, are not the only ones reaping the benefits of working with the ISUG but that other residents are also affected positively (Sileji, 2013).

4.5 Conclusion

This chapter gave the findings based on the various questions that were established during the different phases of the project. The preliminary questions, which were established during Phase 1, spoke to the status quo, and thereby populated the systems knowledge base. Along with the literature review in Chapter 2, Section 4.2 gives the reader a detailed understanding of the life-world problem. The literature review populated the academic and theoretical paradigm, by establishing the broader context within which the life-world problem is situated, namely the history of waste, the social aspect to waste management and the history behind, and discourse on, informal settlement upgrading. Section 4.2 dealt with the problem in the life-world by looking at various aspects of the problem from the different perspectives of the various stakeholders, thus populating systems knowledge of the practical world specific to a particular life-world scenario.

Therefore, systems knowledge is populated with the following facts: Global culture, as a generalised statement, is that of consumerism. Along with that comes a 'cradle-to-grave' design that dominates modern manufacturing. This means that products are predominantly designed to follow a linear, one-way process that renders products useless after a certain timeframe and they end up in a 'grave', such as a landfill, incinerator or even the ocean. Not only does this mean that as the world population grows, so does the amount of waste that is produced, while landfill space dwindles, but also that resources are extracted for consumption and are unable to be recycled, reused or upcycled, as authors McDonough and Braungart (2002) have argued. Hence, waste is accumulating and resources are dwindling. This calls for an urgent reinvention of the system, as well as consumer behaviour, which works towards creating a closed system where resources can be reused. In the case of food waste, nutrients need to be recycled by ensuring their return to the soil.

Along with this global waste problem, are the problems of extreme poverty and the expansion of informal settlements worldwide. In South Africa, the housing policy has called for the incremental in situ upgrading of informal settlements. This policy, although forward-thinking in theory, has been lagging in uptake on the ground. This study, thus, combined the problem of waste management and incremental informal settlement upgrading in a transdisciplinary case study that was applied in a life-world setting. The contextualisation of the study within the life-world populated systems knowledge further with the practical aspects of the problem that Enkanini residents and Stellenbosch Municipality are facing. This includes the problem of irregular waste removal for Enkanini residents, a waste management system that is ineffective and ill-suited to the environment of Enkanini and municipal service backlogs along with drastic landfill constraints. Further aspects of systems knowledge included researching alternative waste management models that had been implemented successfully in South Africa, such as by Tedcor (Pty) Ltd and TrashBack. Lastly, systems knowledge included categorising the waste streams of Enkanini and establishing that a majority of waste produced in the settlement is food waste.

Phase 2 of the study consisted of establishing target knowledge amongst stakeholders, which included determining the kind of intervention and designing the model in the form of a pilot project. Pockets of target knowledge were present amongst stakeholders who indicated tacit knowledge of a more sustainable and effective food waste management system that would increase the living standards of the settlement. The intervention that was decided upon was the bokashi method, which would allow residents to separate and store food waste in a container without unpleasant odours or the risk of attracting pests. The bokashi method also allowed for all food waste to be processed in this manner, whether it is animal protein and fats or cooked waste. This meant that the most problematic wastes, such as animal protein, could be removed from the concrete bays, unlike what a processing method such as composting or anaerobic digestion would have been able to achieve. This, theoretically, made bokashi an overall convenient method that suited the conditions of Enkanini and worked within the constraints of limited human and infrastructure capacity. The theory of the practicality and sustainability of the method was then tested in an intervention in Phase 3.

Phase 3 consisted mainly of integrating target knowledge amongst all stakeholders, which included municipal officials, ward councillors and politicians, co-researchers and pilot participants. The main integration tool was the pilot project itself, which created an experiential learning environment and facilitated the production of tacit knowledge. Tacit

knowledge included the findings to the sub-questions of the pilot project, which showed a high adoption rate amongst participants, positive impacts on living conditions, an increased capacity amongst co-researchers to engage in service delivery issues and the potential to beneficiate waste through two possible closed loop systems. Furthermore, the pilot project established transformation knowledge in that it indicated the beginnings of a change process. This conclusion comes from the continued interest shown in the project, not only by Enkanini residents, but also by municipal officials, ward councillors and funders. To fully integrate this transformation knowledge and thus to bring about a fully functioning and sustainable waste management system for Enkanini, further research is required and further iterations of the project are needed. This will be covered in the final chapter.

Chapter 5 Concluding arguments and areas for further research

5.1 Introduction

This chapter revisits the overall aim of the study to evaluate whether it was achieved and whether the primary research question was answered. Following this, further conclusions are made that emerged through this study. The chapter ends off by listing areas for further research.

The overall aim of the study was to contribute to increasing the sustainability of the waste management system in Enkanini. The primary research question that was established towards the end of Phase 1 will be discussed in the following section.

5.2 Answering the primary research question

The primary research question emerged through contextualising the study in the life-world, as was explained in Chapter 3. The results of the waste characterisation study pushed the study to address the issues caused by food waste in Enkanini, which led to the research question:

What are the alternative food waste management systems that are imminently implementable in Enkanini that will improve social, economic and environmental sustainability?

As explained, bokashi was chosen as the intervention method, and thus only this one alternative waste management system was evaluated in depth. Due to the minimal infrastructure this method required, implementation could proceed immediately, thus making it possible to include the pilot project into the Master's timeline. The potential that the bokashi method has to improve social, economic and environmental sustainability could be evaluated through the findings of the pilot project. The following sections will draw conclusions on the social, economic and environmental sustainability achieved by the pilot project and the study as a whole.

5.2.1 Social sustainability

Social sustainability, in broad terms, refers to communities that provide a good quality of life, and are equitable, diverse, connected and democratic. Therefore, the impact of the pilot project on community life and whether the quality of life was improved through the study will be evaluated.

The findings in the previous chapter show that social learning did take place as a result of the pilot, prompting some residents to continue with the method of food waste separation even after the pilot project had concluded. This indicates that the study had a positive impact that prompted behavioural change in at least 60 residents, who found the benefits of the method valuable enough to carry on with it. The feedback from participants pointed to an increased quality of life through decreased foul odours and a decreased rat population in their immediate environment. Foul odours indicate the presence of pathogens, and rats carry diseases, so both pose health risks to residents.

The study also connected residents to each other through the shared experience of using bokashi, which led to the first peaceful gathering of a larger number of Enkanini residents to celebrate the end of the pilot project. A more democratic process has been initiated through the study by increasing the capacity to engage amongst co-researchers. This refers to an increased capacity to engage in service delivery issues with various actors from different knowledge paradigms. The pilot project was also the first time the municipality successfully engaged around a service delivery aspect with Enkanini residents, and although this engagement was indirect, as it was implemented through a middleman, it shows that positive engagements are possible.

5.2.2 Environmental sustainability

The project had a minimal impact on the environment during the pilot phase due to its size. There are 2 500 households in Enkanini, of which only 100 participated in the pilot project. However, the potential of the positive environmental impact this project can have was indicated through this trial in that if all food waste were removed from the concrete bays, there would be no toxic leachate contaminating the environment. Furthermore, what is first classified as waste is transformed into a reusable product, either through composting, which aids in keeping soils healthy, anaerobic digestion, which harnesses methane gas from organic waste that can be used as an energy source or through BSFL, which turn organic food waste into animal protein. This also means that less waste is taken to landfills, which have a negative environmental impact.

Bokashi has a positive environmental impact in that the microorganisms added to the food waste increase soil quality and can therefore be used as a fertiliser (Koh *et al.*, [n.d.]; Merfield, 2012). This is an important contribution as commercial agriculture has degraded soil quality through methods such as monocrop farming and the use of chemical pesticides and herbicides, as was mentioned in Chapter 3.

Lastly, the study indicates an impact on food production. Although the opportunities of growing food from the composted food waste was not evaluated in depth due to time constraints, the study indicated that linking food waste to food production is possible if pursued more aggressively, as was mentioned in Chapter 4. Supplementing soil with bokashi food waste not only increased its nutrient levels but also increased crop yields.

5.2.3 Economic sustainability

Economic sustainability refers to decoupling environmental degradation and economic growth by factoring in social, environmental, health and monetary costs. Unfortunately, a full analysis of the costs in monetary value was not completed, and only the financial costs of the pilot project were evaluated. Financially, the project is expensive relative to other options that were evaluated in a costing model for Stellenbosch Municipality. However, none of these evaluations factor in the external costs that would indicate the economic sustainability, such as environmental, social and health costs.

Although the external costs were not given a monetary value, the project does indicate that there is job creation and local economic development potential that could be harnessed. This would create social and economic benefits for Enkanini and, on a greater scale, South Africa. Social benefits also include an increased quality of life for residents. The health benefits were mentioned under social sustainability in Section 5.2.1 and include reduced pathogen and rat infestations and the environmental benefits were described in the previous section.

5.3 Conclusions on bokashi as an alternative waste treatment method

The outcomes of the study show that the bokashi method is a socially, environmentally and economically sustainable waste management option for Enkanini. Given this outcome, a NPC by the name of Carbon Life has been registered, with me as one of the directors, which is mandated to pursue and enable the further implementation of bokashi in Enkanini, as well as in other wards of Stellenbosch. Carbon Life has applied for funding from the Green Fund (DBSA) and if funding is granted, Carbon Life hopes to scale up the pilot project to include 5 000 households in Enkanini that will separate their food waste using the bokashi method.

The following paragraphs will draw further conclusions of what was determined through this study.

5.3.1 Positive outcomes are linked to strong relationships

The positive outcomes of the study were largely dependent on the strong relationships that were established with all actors/stakeholders involved in the study. A hands-on approach and intense, proactive engagement in the process ensured that I was able to navigate relationships and resolve conflict in a facilitator and leadership role. Personal attributes also played a role in the positive outcomes, namely good social skills, an ability to see and understand other people's perspectives, the ability to read and decipher body language and a very diplomatic nature. These personal attributes ensured that relationships were kept intact and that potential conflict was addressed and dealt with efficiently. A guiding principle during involvement with actors was the knowledge that perception represents the reality of the respective perceiver. Therefore, it is important to integrate that perception into one's own reality when engaging with it.

5.3.2 Such a project can start a change process

The project alone did not have an impact on the overall waste management system in Enkanini, as it was too small in size and too short in time. However, it did start a change process, indicated by establishing transformation knowledge, that, if nurtured, could bring about lasting change in terms of waste management practices, increased capacity to engage and partnership opportunities, not only for Enkanini but for other wards in Stellenbosch as well. Transformation knowledge was visible in municipal officials that are searching for ways to continue with the project. For example, Haider suggested that in his opinion the best chances of continuing with this waste management method would be to use a NPC as a vehicle to implement it. This advice was followed, and Carbon Life was established and registered with this purpose in mind, as mentioned before.

Transformation knowledge was also established amongst co-researchers. For example, Tyawa has expressed interest in coming on board with the NPC in order to enable the continuation of bokashi as a waste management method in Enkanini.

5.3.3 Regular service influences adoption rate

One of the conclusions drawn from this study is that a regular service will increase the adoption rate amongst residents, or the compliance with the terms and conditions of that service. This conclusion is drawn from the feedback given by participants in the survey that was administered at the end of the pilot and that was discussed in Chapter 4. 20% of the participants indicated that the biggest motivating factor in participating was that they had a

designated area for their food waste and they knew that they would regularly be able to drop off their waste at the ERC, every Saturday morning.

5.3.4 Higher levels of tacit knowledge influence adoption rate and hence behaviour change

Through interviews with residents who chose to continue using bokashi after the conclusion of the pilot project, it was determined that the main motivational factors for continuation included the knowledge that this method would lead to benefits of decreasing bad odours and increasing overall quality of life (Pamana, 2013a; Pamana, 2013b). The knowledge that an alternative waste management method will increase quality of life is part of tacit knowledge. Participants who did not continue using bokashi after the end of the pilot gave reasons that included inconvenience factors like the drop-off centre that was too far away or buckets that were too heavy. This indicates that levels of tacit knowledge are higher amongst users that continued with bokashi. Therefore, it can be deduced that higher levels of tacit knowledge influence adoption rate, which can also be posited as influencing behaviour change.

5.3.5 Creating experiential learning environments is crucial in integrating knowledge

A key difference in the execution of the study and the TD processes described in the literature is that experiential learning was the most useful environment in which to integrate knowledge amongst stakeholders. The TD literature lists various integration tools (Pohl & Hirsch Hadorn, 2007) but never refers explicitly to the role that experiential processes have. Cognitive processes in the context of this study would not have been very effective, as was proven by the discussion held with co-researchers around alternative waste management systems. Increasing experiential knowledge was a crucial boundary object that took the form of a pilot project and field trips, as these actions increased levels of tacit knowledge. The field trips and boundary objects were very beneficial to actors as they could relate to these and thus participate and engage in a meaningful manner in the study, as was experienced with the co-researchers.

5.4 Has the overall aim of the study been achieved?

The overall aim set at the beginning of the process was to contribute to increasing the sustainability of the Enkanini waste management system. This aim has been achieved to a certain degree, as behaviour of a number of residents has changed to accommodate the alternative waste management system and thus move towards improved sustainability. Further, the bokashi method continues to be used in Enkanini, thus diverting a percentage of

food waste from landfill and transforming waste into a more valuable product. These are indications that a change process has started and, if nurtured and driven, it is believed that a full transformation process of the waste management system can be achieved in the future.

5.5 Areas for further research

As indicated throughout the chapters, there are opportunities for further research that arise from this study, which are listed here.

5.5.1. Researching the possibilities of closing the loop

The first aspect that needs to be researched, is evaluating the full potential of food production from soils that have been supplemented with bokashi food waste to determine how much food waste can be processed in this manner. This research would determine the possibility of closing the loop and containing benefits within the system, as was alluded to in Chapter 4. The research would have to determine whether such a closed-loop system is sustainable and whether there is a demand for the food grown, either within the settlement or, if not, by selling it at farmer's markets or to restaurants to create a revenue stream. If there is a demand within the settlement for the vegetables grown through this method then food production could be linked to increasing food security, and to increasing the nutritional value of food consumed by residents. It could then also be measured what impact this has on their general health and wellbeing.

A further area of research is the possibility of closing the economic loop of the project, namely determining whether a revenue stream can be established from any of the above-mentioned processing methods and whether this revenue can cover the costs of the project as well as return profit to participants. This research would most probably have to be conducted at the same time as researching the closed loop food production model, as the amount of food waste produced within Enkanini is too much to only be processed through this option. Therefore, multiple processing methods would most likely be needed to cope with the amount. The type and number of methods would depend on how many people adopt this method within the settlement. For example, a co-op model could be evaluated as the vehicle to implement the economic closed-loop system.

5.5.2 Researching the economic impact of the bokashi method and project

In order to determine the full economic sustainability of the bokashi method, further research and work has to be done to attribute a monetary value to the benefits and disadvantages that this method has, for example determining the value of external costs such as environmental

impacts, health impacts and impact on living conditions. To determine the long-term benefits of the project, a second phase of the pilot would have to be implemented that comprises more participants and runs for a longer time period. This would also indicate whether the change process that was initiated through this study has accumulated enough momentum to carry on and bring about a transformation of the waste management system, thereby integrating transformation knowledge. Another phase of the project could also be used to research the potential for local economic development within Enkanini through the project, and the economic impact this has for the municipality.

5.5.3 Researching additional alternative processing and management methods

As this study only evaluated one food processing method in depth, there is scope for further research into various other processing methods and how these would fare in terms of adoption rate, logistical ease and other factors affecting the overall sustainability of the project. Research could, for example, be done on comparing the cost of various alternatives, the adoption rate amongst residents and the total benefits to residents as well as to the municipality.

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Appendix A: List of Personal Communications

Barnard, R. 2012. Personal interview: Tedcor's operations and history. 2 May, Cape Town.

Biscombe, P. 2013. Meeting: Way forward for Bokashi. 13 August, Stellenbosch.

Brent, A. 2012. Discussion: Life costing model. 26 July, Stellenbosch.

Botha, J. 2012. Personal interview: Tedcor's operations and challenges. 25 June, Rustenburg.

De Lubbe, M. 2013. Personal interview: Recycling in Stellenbosch. 1 July, Stellenbosch.

Galada, M. 2012. Discussion: Problems with waste system in Enkanini and history. 15 March, Stellenbosch.

Glick, G. 2012. Personal interview: Tedcor's operations and business approach. 10 May, Cape Town.

Goldman, M. 2012. Personal interview: Tedcor's unique business model. 26 June, Johannesburg.

Haider, S. 2012. Personal interview: Enkanini and Stellenbosch waste system. 15 March; 14 May; 12 July, Stellenbosch.

Haider, S. 2013. Personal interview: Reflections on Bokashi Project. 1 July, Stellenbosch.

Haider, S. & Petersen, E. 2012. Discussion: Waste management system in Enkanini. 6 June. Stellenbosch

Houghton, J. 2012. Personal interview: History of Tedcor and business operations. 20 April, Knysna.

ISUG. 2012. Discussions: Reflections on research. 3, 19, 24 April; 26 July, Stellenbosch.

Keller, A. & Wessels, B. 2012. Discussion: Reflection on research. 16 May. Stellenbosch.

Kotze, C. 2012. Personal interview and discussion: Introduction to BSFL. 4 June, Stellenbosch.

McNaught, A. 2012. Personal interview: TrashBack operations and approach. 30 July, Hout Bay.

Mpela, Y. 2012. Personal interview: Experience with Tedcor service. 24 June, Johannesburg.

Mthelo, M.V. & Sileji, N.S. 2012. Meeting: Designing the pilot project. 13 September, Stellenbosch.

Nemukula, V. 2012. Meeting: Tedcor presents to SM as an outsourcing option. 10 May, Stellenbosch.

Nomvilisu, P. 2012. Personal interview: Problems with waste system in Enkanini. 7 March, Stellenbosch.

Nsokotha, N. & Tyawa, Y. 2013. Discussion: History of Enkanini. 2 July, Stellenbosch.

Pamana, A. 2012. Personal interview: Benefits of bokashi. 11 December, Stellenbosch.

Pamana, A. 2013. Personal interview: Reflections on bokashi project. 14 August, Stellenbosch.

Pamana, P. 2013. Personal interview: Reflections on bokashi project. 8 August, Stellenbosch.

Petersen, E. 2012. Personal interview: Problems with Enkanini waste system. 25 May, Stellenbosch.

Reggia, A. 2012. Personal interview: Experience with Tedcor service. 25 June, Johannesburg.

Retief, P. 2012. Meeting: Bokashi as an option for other wards. 3 October, Stellenbosch.

Rüst, A.F. 2012. Discussion: Design of trolley for pilot project. 20 September, Stellenbosch.

Sileji, N.S. 2013. Personal interview: Reflections on bokashi project. 26 July, Stellenbosch.

SITT. 2012. Meetings: Alternative approaches to infrastructure and service delivery. 9, 17 February; 16 March; 13 April; 17, 25 May; 22 June; 6, 20 July; 3, 17, 29, 31 August; 14, 28 September; 12 October; 16, 30 November, Stellenbosch.

Smit, C. 2012. Demonstration and discussion: Lasagne composting with Bokashi. 31 October, Stellenbosch.

Swilling, M. 2013. Discussion: Reflection on research progress and update. 6 May, Stellenbosch.

Tavener-Smith, L. 2013. Personal interview: Reflections on bokashi project. 8 July, Stellenbosch.

Tyawa, Y. & Sileji, N.S. 2012. Discussion: Designing the pilot project. 2 October, Stellenbosch.

Tyawa, Y. 2012. Discussion: Designing the pilot project. 18 September, Stellenbosch.

Tyawa, Y. 2013. Personal interview: Reflections on bokashi project. 15 July, Stellenbosch.

Tyawa, Y., Mthelo, M.V. & Sileji, N.S. 2012. Discussions: Problems with current system and possible alternatives. 15 March; 4, 7, 11, 15, 18, 21, 22 May; 17 August, Stellenbosch.

Van der Merwe, R. 2012. Personal interview and discussion: Introduction to bokashi. 19 July, Stellenbosch.

Van der Merwe, R. 2013. Personal interview: Reflections on bokashi project. 8 August, Stellenbosch.

Van Niekerk, A. 2012. Personal interview: Infrastructure and service backlogs. 17 May, Stellenbosch.

Wessels, B. 2012. Discussion: Reflections on research process. 16 August, Stellenbosch.

Wessels, B. 2013. Personal interview: Reflections on bokashi project. 9 July, Stellenbosch.

Zukiswa, N. 2013. Personal interview: Reflections on bokashi project. 14 August, Stellenbosch.

Appendix B: Definition of key terms and concepts

A *boundary object* is any object to which all actors involved in the study/project are able to refer based on their specific interests in shaping things and through which communication is enabled and knowledge is integrated without the requirement of explicit communication between the various perspectives of the different actors (Pohl & Hirsch Hadorn, 2007).

Bringing results to fruition refers to the actions of an intervention in the life-world that enables further learning processes. It usually takes place in Phase 3 of the TD research process.

Collaboration forms refer to the way in which group work is organised and structured between actors involved in the study (Pohl & Hirsch Hadorn, 2007).

Economic sustainability is one of the three tiers of sustainability and in broad terms includes decoupling environmental degradation and economic growth by factoring in social, cultural, environmental, health and monetary costs.

Environmental sustainability refers to one of the three tiers of sustainability that includes aspects of healthy ecosystems and sustainable consumption of natural resources that impacts land, air, water, energy, food and waste.

Experiential learning or knowledge refers to learning that takes place in, or knowledge that is acquired through, experience of the life-world, as compared to knowledge that is acquired through linear cognitive learning.

Explicit knowledge refers to knowledge of facts, things or states that we are conscious of learning (Darby, 2006).

Life-world refers to the human world prior to scientific involvement (Hirsch Hadorn *et al.*, 2008). In this thesis, the term is used to refer to the everyday world.

Recursiveness is a characteristic of the TD process that refers to the iterative nature of both the entire process as well as its individual phases, in a continuous cycle of problem identification, analysis, intervention and reflection.

Social sustainability refers to one of the three tiers of sustainability. The social element of sustainability includes communities that provide a good quality of life and are equitable, diverse, connected and democratic.

Systems knowledge concerns itself with questions about the genesis of a problem, and how these are interpreted in the life-world (Pohl & Hirsch Hadron, 2007), i.e., “What do we have

currently?" Systems knowledge is therefore often associated with the status quo of what exists already.

Tacit knowledge is an unconscious type of knowledge that refers to knowledge of the everyday. The higher the level of tacit knowledge is within an actor, the easier it is to initiate behaviour modifications and thus transform tacit knowledge into explicit knowledge. In this study, tacit knowledge is freely interchanged with the term 'experiential knowledge'.

Target knowledge concerns itself with questions that are related to the need for change and that determine what the desired goals and better practices are (Pohl & Hirsch Hadorn, 2007), i.e., "What do we want instead?" Target knowledge therefore relates to knowledge of an ideal that is desired.

Transformation knowledge concerns itself with questions about the means to change existing practices to lead to new, desired practices, i.e.. "How do we get there?" Transformation knowledge therefore relates to knowledge of actions and processes required to achieve the ideal.

Appendix C: List of Tedcor Interviews

Date	Interviewee	Position held
5 April 2012	Rudie Barnard	Project manager: Western Cape
20 April 2012	John Houghton	Chairman
10 May 2012	Gavin Glick	Director
24 June 2012	Jaco Botha	Regional manager: Gauteng
25 June 2012	Isaac Nhlapo	Project manager: Mogale City – Kagiso
25 June 2012	John Mathikinca	Truck driver
25 June 2012	Jabu Tshabalala	Truck driver
26 June 2012	Harold Dlamini	Truck owner/driver
26 June 2012	Sara Nxumalo	Resident receiving Tedcor's services
26 June 2012	Lena Mjali	Waste picker
26 June 2012	Kelebogile Motlhabane	Waste picker

26 June 2012	Hazel Nxele Makhatini	Resident receiving Tedcor's services
26 June 2012	Reggia Mathonsi	Resident receiving Tedcor's services
28 June 2012	Michael Goldman	Professor: Gordon Institute of Business Science

Appendix D: List of field trips, or experiential learning opportunities, undertaken during the research study

Date	Field trip destination	Purpose of field trip
21 June 2012	Stellenbosch – Probiokashi (Pty) Ltd Factory	Learning about bokashi and the functions of microorganisms in food waste processing
24–29 June 2012	Johannesburg – Tedcor	Exposure to operations and interviews
28 July 2012	Hout Bay – TrashBack	Learning about recycling initiatives for informal settlements
4 August 2012	Greyton – Trash to Treasure Festival	Exposure to upcycling projects and initiatives
31 August 2012	Elsenburg – AgriProtein Fly Farm	Learning about black soldier fly larvae as a food waste processing option
5 September 2012	Legacy Community Centre - Kayamandi	Exposure to planting vegetables with bokashi compost and a functioning and successful community garden with few resources
11 September 2012	Knorrhoek Wine Farm – Vegetable Garden	Exposure to planting vegetables with bokashi compost