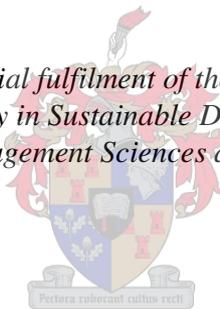


Ecological Food Sense: Connections between food waste flows and food production in Enkanini Informal Settlement, Stellenbosch

by
Michelle Claire Mollatt

*Thesis presented in partial fulfilment of the requirements for the degree
of Master of Philosophy in Sustainable Development in the Faculty of
Economic and Management Sciences at Stellenbosch University*



Supervisor: Prof. Mark Swilling

Cr tln2014

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ABSTRACT

In situ Informal Settlement Upgrading (ISU) was explored in this thesis, focussing on its relevance to waste service upgrading options immediately available and practically implementable for residents of Enkanini, a poorly serviced township (slum) in Stellenbosch, South Africa. Household food waste (kitchen scraps) was chosen as a key point of entry for exploring the context and viability of *in situ* improvement of solid waste management services in the area. This was done by investigating ways biological and social aspects of soil quality and food waste management can be incrementally improved in the settlement. Transdisciplinary methodology, Participatory Action Learning and Social Learning perspectives, combined with ecological thinking were used to explore different methods of managing food waste in Enkanini. A food waste collection pilot project was initiated in Enkanini by the Stellenbosch Municipality in 2012. The project was modified and continued in 2013, which served as the case study for this thesis. In 2013, food waste was collected by 56 households over five months. It was treated with Bokashi Effective Micro-organisms (Bokashi EM) containing yeasts, lactic acid bacteria, actinomycetes and photosynthetic bacteria. The Bokashi EM partially fermented the waste before it was used for composting or feeding to Black Soldier Fly (*Hermetia illucens*) larvae. Laboratory testing of food waste, compost, soils and larvae waste residue determined the safety, potential and sustainability of food waste for recycling and contribution to local urban agriculture by closing the organic waste loop, and for generating an income stream. A total of 5851kg food waste was collected, saving 6m³ landfill space. Households generated 5,2kg - 9,6kg food waste per week. Extrapolating this lower figure for all of Enkanini (about 2400 households), about 50,2 tonnes of food waste could be generated per month. If this were collected and recycled or composted, this would save 51,2m³ landfill space per month. The most commonly cited benefit of food waste collections by participants was reduction of vermin in or around their homes. Laboratory testing indicated that some samples had high levels of *Escherichia coli* (*E. coli*) bacteria. No traces of *Salmonella* were found in food waste, compost and soil samples, and most were within acceptable limits for heavy metals. It was cautioned that vegetables grown on soils or compost with high *E. coli* be washed or cooked before consumption. Following socially and ecologically sustainable management of Enkanini's food waste requires a combination of waste management methods. Options include localised composting - burying EM treated food waste in soil; *in situ* container composting of waste and adding this to soil; processing of EM treated food waste by Black Soldier Fly larvae (and their subsequent use as feed for chickens or fish); and finally by anaerobic digestion for generation of biogas and effluent fertiliser in local biodigestors. The thesis showed that biological elements (such as bacteria and soil nutrients) have impacts on residents in communities and these need to be considered significant. The thesis suggests ecological elements be considered as indicators or building blocks for ISU locally, nationally and internationally.

Keywords: *in situ* incremental upgrading, food waste management, Effective Micro-organisms, social learning, urban agriculture, closed-loop systems, organic waste management, informal settlements.

OPSOMMING

In situ Opgraderingsprojek vir Informele Nedersetting (OIN) is in hierdie tesis ondersoek, met die fokus om die relevansie van afval diens opgradering opsies prakties te implementeer vir die inwoners van Enkanini, Stellenbosch, Suid Afrika, 'n gemeenskap met swak dienslewering. Huishoudelike kombuis voedselafval is gekies om die konteks en lewensvatbaarheid van in situ verbetering van vaste afval bestuur dienste te ondersoek. Dit is bereik deur maniere te ondersoek om die biologiese en sosiale aspekte van die kwaliteit van grond en voedselafval bestuur in die nedersetting te verbeter. Transdissiplinêre metode, Deelnemende Aksie Leer en Sosiale Leerprosesse, gekombineer met ekologiese denke, is gebruik is om verskillende metodes van die bestuur van voedselafval in Enkanini te verken. 'N Enkanini voedselafval versamelingsprojek is in 2012 deur die Stellenbosch Munisipaliteit begin. Dit is in 2013 aangepas en vir hierdie studie gebruik. Gedurende vyf maande in 2013 is voedselafval deur 56 huishoudings ingesamel. Dit is behandel met Bokashi effektiewe mikro-organismes (EM Bokashi) met gis, melksuur bakterieë, aktinomisete en fotosintetiese bakterieë. Die Bokashi EM het die afval gedeeltelik gegis voordat die afval gebruik was vir kompos of voeding aan Swart Soldaat Vlieg (*Hermetia illucens*) larwes. Voedselafval, kompos, grond en larwe oorskot laboratourim toetse het die veiligheid bepaal, asook die potensiaal en volhoubaarheid van die afval vir herwinning en die bydrae tot die plaaslike stedelike landbou deur middel van die organiese afval siklus, en vir inkomste generering. 5851kg voedselafval is ingesamel en 6m³ se opvullingsruimte bespaar. Die huishoudings het 5,2kg – 9,6kg voedselafval per week gegenereer. Die laer syfer in aggeneem, kan sowat 50,2 ton voedselafval per maand in Enkanini (ongeveer 2400 huishoudings) gegenereer word. As dit ingesamel, herwin of gekomposteer was, sou 51,2 m³ opvullingsruimte per maand bespaar word. Die belangrikste voordeel van die voedselafval versamelings was die vermindering van knaag en aasdiere rondom wonings. Laboratoriumtoetse het hoë vlakke van *Escherichia coli* (*E. coli*) bakterieë in sommige monsters gevind. Geen spore van *Salmonella* is in die voedselafval, kompos en grondmonsters gevind nie en meeste was binne die aanvaarbare perke vir swaar metale. Die gemeenskap is gewaarsku om groente wat in die grond of kompos gekweek is voor verbruik in chloorwater te was of kook. Die sosiale en ekologiese volhoubare bestuur van Enkanini se voedselafval vereis 'n kombinasie van afval bestuursmetodes. Opsies sluit gelokaliseerde kompos - begrawe EM behandelde voedsel afval in die grond; in situ houer kompos afval en die toevoeging van hierdie tot die grond; verwerking van EM behandelde voedselafval deur Swart Soldaat Vlieg larwes (en hul daaropvolgende gebruik as voer vir hoenders of vis); en uiteindelik deur mestvergisting vir die generasie van biogas en kunsmis in biovergisters. Die tesis toon dat biologiese elemente (soos bakterieë en voedingstowwe in grond)'n impak het op die gemeenskap se inwoners en as 'n belangrik faktor beskou moet word. Die tesis dui ekologiese elemente as 'n toekomstige aanwysers aan indien OIN plaaslik, nasionaal of internasionaal oorweeg word.

Sleutelwoorde: *in situ* toenemende opgradering, kos afval bestuur, effektiewe mikro-organismes, sosiale leerprosesse, stedelike landbou, geslotestelsel-sisteme, organiese afval, informele nedersettings.

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LIST OF ABBREVIATIONS AND ACRONYMS:

AFSUN	African Food Security Urban Network
ANT	Actor-Network Theory
BNG	Breaking New Ground
CORC	Community Organisation Resource Centre
DBSA	Development Bank of South Africa
EM	Effective micro-organisms
FAO	Food and Agriculture Organisation of the United Nations
FSI	Food Security Initiative
HSRC	Human Sciences Research Council of South Africa
TSAMAHub	Transdisciplinary Sustainability Analysis, Modelling and Assessment Hub
IFAD	International Fund for Agriculture Development
IFPRI	Institute for Food Policy Research
IFSS	Integrated Food Security Strategy
ISU	Informal Settlement Upgrading
ISUG	Informal Settlement Upgrading Group
IDP	Integrated Development Plan
IWMP	Integrated Waste Management Plan
MDG	Millennium Development Goal
NEXUS	National Research Foundation Research Support and Knowledge Networking Databases
NGO	Non-Governmental Organisation
NiPad	Africa-Wide Information research database
NPO	Non-Profit Organisation
NRF	National Research Foundation
NWMS	National Waste Management Strategy
PAR	Participatory Action Research
SADC	Southern African Development Community
SANHANES	South African National Health And Nutrition Examination Survey
SL	Social Learning
SLSFS	Social Learning for Sustainable Food Systems
STATS SA	Statistics South Africa
UA	Urban Agriculture
UISP	Upgrading of Informal Settlements Programme
UN	United Nations
UNEP	United Nations Environment Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Education Fund
UNOCHA	United Nations Office for the Co-ordination of Humanitarian Affairs
UPA	Urban and Peri-urban Agriculture
US EPA	United States Environmental Protection Agency
WCED	World Commission on Environment and Development
WFP	World Food Programme

Chapter 1: Introduction

“Fortunate are those who take the first steps.”

Paulo Coelho – excerpt from “By the River Piedra I Sat Down and Wept”

1. Introduction

In this thesis, some biological and social aspects of improved food waste management were explored in the context of *in situ* and incremental upgrading of services and infrastructure in an informal settlement (slum) in South Africa. These improvements were tested within the context of incremental *in situ* upgrading as it is described by the Upgrading of Informal Settlements Programme (UISP) in the South African Government’s housing policies. These policies are being explored by a transdisciplinary group of researchers at the Sustainability Institute at Stellenbosch University. The UISP forms part of the Breaking New Ground (BNG) housing policy which was introduced by the government in 2004 (Keller, 2012). The BNG policy was promulgated to mandate local governments to create sustainable human settlements through local upgrading (Keller, 2012). The policy is aimed to address the weaknesses of South Africa’s Reconstruction and Development Plan (RDP) policies for low-cost housing (Keller, 2012). However, despite several mechanisms for carrying out the BNG policy, it has not been successfully adopted (Keller, 2012). Although the reasons for this could be numerous, one explanation may be that there are few practical and demonstrated examples of pilot projects for successful *in situ* service upgrading in the country (Keller, 2012).

In response to this lack of practical examples, the researcher questions, contextualises and documents some social, biological and practical challenges of waste management service delivery. These challenges are placed in the context of food waste (kitchen scraps) management in an under-serviced informal settlement in the Western Cape of South Africa. This is done using the case study of an ongoing pilot project for biological food waste management in Enkanini, a slum located within walking distance of Stellenbosch, South Africa.

Before the initial pilot study preceding this research was carried out in 2012, research into aspects of food waste management had not been done in the Enkanini or Stellenbosch areas. The lack of baseline data on food waste, composting and food production in Enkanini signals a critical need for research into these aspects of the daily lives of residents in this informal settlement. Information relating to challenges of urban poverty are needed for the following reasons:

- to inform operations of future initiatives, businesses, social enterprises and Non-Profit Organisations (NPO's);
- to motivate, justify and direct government attention and investment in informal settlements;
- to guide future research; and
- to inform the underlying national, provincial and local government policies relating to all aspects of the food system.

In addition, this thesis attempts to understand how solutions to daily problems associated with public health and domestic services such as solid waste management can be formulated and grown from the ground up, and particularly by residents themselves. It is proposed that this be done by recognising and harnessing existing local skills, labour and resources in informal settlements. This thesis documents some aspects of what the beginning of this kind of learning journey has meant from a social, biological and ecological perspective at the community level for the project participants in Enkanini, as well as for researchers involved.

Ultimately, the researcher believes that it is invariably the human needs in slums that are addressed as priority action points by government, non-governmental organisations and researchers. Nevertheless, she aims to illustrate that the importance of ecological health in these areas should not be underestimated, given that parts of the environment can have both significant positive and negative impacts on the quality of life of slum dwellers. This is especially the case in slums where service delivery is poor to non-existent. The impacts which biological / ecological elements (such as soil, nutrients and microbes) can and do have on service delivery in informal settlements as well as the ecosystems on which these areas depend are profound. Considering humans and biological elements in the informal settlement context is critical for both human and environmental health. This is because people living in these areas are generally more vulnerable to the negative effects of poor environmental conditions, to which both humans and biological elements contribute. Similarly, it is useful to consider that due to the infrastructure and environmental conditions in slums, biological elements are often more likely to be exposed to negative human activities (such as soil and river pollution or the spread of diseases associated with poor hygiene).

In order to begin to formulate a compromise between the prioritisation of human needs and the health of the natural environments in informal settlements, a systematic prioritisation of needs

should be followed. Statistical information on health levels and demographic characteristics are used by decision-makers to prioritise different activities needed in slums. Similarly, when considering environments where slums are located, a case needs to be made for the money, time and energy spent on addressing the issues associated with aspects of environmental health. Of course, this kind of prioritisation needs to be done in a participative way, where residents are able to discuss and raise points about issues they may identify as priorities.

In this research, some characteristics of the environmental health of Enkanini are uncovered. In doing so, it is shown that the ecological impacts of parts of these natural systems on residents and communities should be considered to be significant. These impacts should merit the consideration of ecological elements and ecological health as indicators or building blocks for *in situ* informal settlement upgrading locally, nationally and internationally.

2. Background to this study

a. HOPE project and TsamaHUB

The HOPE project is a multi-faceted project based at Stellenbosch University, which was initiated in 2010. It facilitates research into Africa and South Africa's 'most pressing challenges' and has a multidisciplinary approach that is based on three main functions – research, community interaction and teaching and learning (University of Stellenbosch, 2010).

Inspired by the HOPE project, the TSAMAHub (Transdisciplinary Sustainability Analysis, Modelling and Assessment Hub) was formed. This is an institutional arrangement consisting of a group of researchers that aims to facilitate transdisciplinary research. The vision of the TSAMAHub is to look for and work on 'long-term, sustainable solutions to the planetary crises facing the African continent through new ways of knowing and producing knowledge ...' (TSAMAHub Website, 2013). The TSAMAHub envisions that this kind of knowledge will enable development of '... an integrated understanding of ... interacting systems, in particular coupled natural and social systems ...' (TSAMAHub Website, 2013). In 2011, the TsamaHUB was awarded funding from the National Research Foundation (NRF) to conduct research into Sustainable Community Transitions (Keller, 2012). This funding enabled the initiation of community action research in Enkanini through the formation of a group of researchers called the Informal Settlement Upgrading Group (ISUG).

b. Informal Settlement Upgrading Group (ISUG) - Transitions Collective

In 2011, a group of students (the Informal Settlement Upgrading Group) at the Sustainability Institute of Stellenbosch University began to negotiate research spaces in the Enkanini settlement relating to basic services delivery and *in situ* upgrading. The ISUG's name has now evolved into the Transitions Collective (the Collective). When it was first formed, the group was given the task of testing sustainable ways to carry out *in situ* upgrading 'in a real life context' (Keller, 2012:1). The

Collective continues to explore what real life and lived-out aspects of *in situ* upgrading mean in practical terms for Enkanini's residents, taken from 'the perspective of the average shack-dweller in South Africa' (Swilling, Tavener-Smith, Keller, von der Heyde & Wessels, 2013:1).

Enkanini's name means 'take by force' (Swilling *et al.*, 2013:10). It was first settled in 2007, when a group of about 50 families invaded the area and built their houses (shacks). This invasion meant the area was declared an illegal settlement by government. An eviction warrant was written to authorise the removal of these settlers. However, in the lapse of time between the arrival of Enkanini's first settlers and the time it took for the warrant to be carried out, a much larger number of settlers (about 2000 households) had arrived in Enkanini. This made it practically impossible to carry out evictions required by the notice, so the settlement was left to itself.

Perhaps as a result of the nature of Enkanini's history, the area does not seem to have any easily recognisable or formal community representation or leadership structures. This means that in order for research to be conducted, researchers liaise by working directly with ordinary residents, who are the Collective's co-researchers. The Collective focuses its efforts on co-creating alternative realities for informal settlement residents, and in so doing, the group has an alternative approach to research. The Collective recognises that the reaction of residents in informal settlements to service delivery promises characteristic of post-apartheid urban development is to '(t)rust and (w)ait' (Swilling *et al.*, 2013:2). As a response to this reaction, instead of residents waiting hopefully for these services to arrive, the Collective's research has more of an activist nature, founded on the question 'what can residents do now?'. A further motivation for taking an activist approach to research is that trusting and waiting for services to arrive '... demobilis(es) civil society since there is nothing to organi(s)e communities around that can result in tangible immediate improvements to daily life' (Swilling *et al.*, 2013:2).

c. Food Security Initiative (FSI)

This research was funded by the Food Security Initiative (FSI), which is also part of the HOPE project. The FSI works on contributing to '... the emergence of a resilient, sustainable food system for Southern Africa' (FSI Website, 2013). The FSI's vision is to do this by 'reconceptualising the food security challenge', and to do so by integrating results from in-depth research on aspects such as:

- Problems in the food value chain;
- Building capacity in players in the various parts of the food system;
- Systematic impact assessment; and
- Collaborating across the boundaries of disciplines (FSI Website, 2013).

The FSI has three work focus areas, namely:

- Sustainable production for safe and nutritious food;
- Utilisation of safe and nutritious food; and
- Post-harvest optimisation (FSI Website, 2013).

This research contributes to a number of these aspects, such as provision of grounded data for evidence of problems in the food value chain, as well as describing the various opportunities and needs for collaboration across disciplines. The composting demonstration aspect of this research provides real data which contributes to knowledge sets on the small-scale production of safe and nutritious food in the context of informal settlements, urban poverty and malnutrition.

d. Continuation of 2012 food waste pilot project

Previous Collective researchers have done studies on ecologically designed houses combined with sustainable energy solutions (see description of the iShack in section 4 of this chapter), sanitation experiments (toilets and biodigestors), waste management, as well as institutional and social arrangements relating to all of these aspects within the Enkanini community.

This research supports the objectives of the Collective in that new researchers continue to build on the work done by previous ones. In this thesis, the process of the continued food waste pilot project which was initially carried out in 2012 by Vanessa von der Heyde, is expanded upon and documented. This continuation and expansion of the work has been done in order to explore and describe the environmental (ecological and biological) and social impacts of the project both on Enkanini residents, researchers and the Stellenbosch Municipality.

The pilot food waste collection project of 2012 ran for nine weeks, from October to December 2012. It was sponsored by the Stellenbosch Municipality in partnership with ProBiokashi (Pty) Ltd. Household food waste (i.e. kitchen scraps) was collected by 100 households in Enkanini who treated it with a Bokashi mixture supplied by ProBiokashi. Bokashi is wheat bran inoculated with effective micro-organisms (EM) (von der Heyde, 2012). These micro-organisms assist with the primary stages of composting or decomposition (via fermentation) (see Chapter 2). They also allow food waste to be stored for longer periods of time without producing unpleasant odours. Bokashi is versatile and can be used to treat food waste of all kinds – including cooked and uncooked vegetables, cooked or raw meat and fish, as well as any bones (von der Heyde, 2012).

Over that nine week period, the pilot project was able to collect 4,5 tonnes of food waste, and each participating household came at least once to the weekly collections (Swilling *et al.*, 2013:4). The efficiency of the participants at separating their food waste was very high, as very little non-food waste was collected (Swilling *et al.*, 2013). Two celebratory barbecues were held for participants and their families, which were probably the first and largest peaceful gatherings related to services in Enkanini (Swilling *et al.*, 2013). These were considered peaceful because Enkanini residents' relationship with the municipality is generally fragile and fraught with tension due to the poor service delivery in the settlement.

With the assistance of Enkanini co-researchers, the 2012 pilot project was able to continue relatively seamlessly into 2013, despite a lack of continued funding and support from the Stellenbosch Municipality. Bokashi that was needed to continue the project was sponsored by ProBiokashi (Pty) Ltd. for the period of January to April 2013. The renewed data collection and monitoring of the 2013 project for the purposes of this thesis began in the middle of April 2013.

3. Motivation for this study

a. Service provision in Enkanini and Stellenbosch

Enkanini residents constantly survive the reality of marginalisation, poverty and poor service provision in South Africa. The area poses particular challenges for service provision infrastructure planning and installation as it has no formal drainage system and is located on particularly steep gradients (Swilling *et al.*, 2013).

The most recent population survey of Enkanini was done in 2012 by the Stellenbosch Municipality and the Community Organisation Resource Centre (CORC). At the time of the survey, the population was estimated to be about 4449 people (Stellenbosch Municipality & CORC, 2012:18). However, the current population of Enkanini is likely to be higher than this. It was found during the 2012 survey that about 46% of the population were women, and that the settlement consisted of about 2494 households (Stellenbosch Municipality & CORC, 2012:18). These households share 32 municipal taps and 80 toilets (Stellenbosch Municipality & CORC, 2012:18). During the survey, it was found that due to some toilets being out of order, the ratio of residents to toilets was 72 people per toilet (Stellenbosch Municipality & CORC, 2012:18). Solid waste service infrastructure includes just seven communal open waste skips (Swilling *et al.*, 2013:1). The settlement is not electrified, and is adjacent to the semi-formal low-income settlement of Kayamandi. Some residents in Enkanini who do have access to electricity are connected informally (i.e. there is some payment agreement between residents) to formal electrical connections in Kayamandi. All these statistics on service access in Enkanini contrast starkly to the data in the Stellenbosch Municipality Integrated Development Plan (IDP) of 2013 on basic service delivery in the Stellenbosch area as a whole. In

that report, it is stated that 97,2% of households have access to hygienic toilets, 96,7% have access to piped water, 98,8% have access to formal electricity connections and 90,7% reside in formal dwellings (Stellenbosch Municipality, 2013:23).

b. Lack of research in informal settlements in South Africa

The paucity of research on informal settlements in South Africa is surprising, given the extremely large numbers of people residing in these areas, and the urgent social, health and environmental challenges which they face. Research that does exist is largely hierarchical and does not often incorporate the voice of those actually living in informal settlements. Furthermore, research that involves the inclusion of slum residents in a participatory research design is a relatively new concept, and projects which manage to do this are only just beginning to emerge around the world. This approach is a key element of this case study, which allows it to contribute to the field of informal settlement upgrading, as well as to participatory research in general.

c. Urbanisation and informal living in South Africa

In 2009, almost one in every four South Africans lived in informal or traditional dwellings (HSRC, 2011:49). This amounted to a total of about 3,3 million households, of which 1,9 million were living in informal dwellings and 1,4 million in traditional dwellings (HSRC, 2011:49). The percentage of the population living in formal dwellings increased only marginally between 2002 and 2011, from 53,1% to 53,6% (Statistics South Africa, 2012:2).

By 2001, about 56,2% of South Africa's population was living in cities, with this proportion predicted to increase to about 70% by 2025 (McLachlan & Thorne, 2009:9). Indeed, it seems that despite many 'aspirations to the contrary', informality and informal settlements will be a reality for South Africa for the medium if not long- term future (Misselhorn, 2008:36).

Urbanisation and rural-urban migration in South Africa are now contributing to unexpected negative health effects in urban residents, especially those living in informal settlements. These health implications include what is now called a 'nutrition transition', (Popkin, n.d.; in Crush, Frayne & McLachlan, 2011). This refers to the influence of urbanisation on changing diets, which is causing over-nutrition or obesity (Crush, Frayne & McLachlan, 2011). The intersection of these elements of informality, service provision, urban agriculture, poverty and under- and over- nutrition is a principal reason for carrying out this research.

d. Food Insecurity in low-income areas in South Africa

Urban informal settlements have the lowest food security conditions of all areas in South African cities. In South Africa, rising food prices mean poor families are forced to spend 60 - 80% of their income on food staples, which pushes these families into situations where they experience poorer

nutrition (Naylor, 2008; in Haysom, 2012:135). Put simply, '(f)ood looms large in the budgets of low-income urban households' (Cohen & Garrett, 2010:469).

Surveys done by the African Food Security Urban Network (AFSUN) in low-income areas in Cape Town recently indicate approximately 80% of these households are moderately or severely food insecure (Battersby, 2011a). Correspondingly, urban food security has been coined 'the new frontier' (McLachlan & Thorne, 2009:8). This may well be an accurate description, given the unexplored and complex territory that feeding an increasingly urbanised world presents.

e. Stellenbosch Landfill crisis

The life span of the Devon Valley landfill site in Stellenbosch has been identified by the Stellenbosch Municipality as one of their 'critical decision areas' (Stellenbosch Municipality, 2013:83). The Stellenbosch Landfill was already full in 2009 (Swilling, 2012). However, waste continued to be disposed on it. In 2009, it was estimated that to dispose of the municipality's waste elsewhere would cost up to R2 million per month (Swilling, 2012). When the landfill was full, its main dumping area exceeded the height it was originally permitted to have - 16 metres above ground level (Resource Management Services, 2012:1). The actual height of the landfill exceeded this permitted height by 7 metres (Resource Management Services, 2012:1). Thus, setting the Enkanini waste context within the greater municipal disposal crisis provides further motivation for the need for case study-specific evidence of simple and easily implementable solid waste management options in the region.

f. Researcher's biological and ecological background

With a background in biology and ecology, the researcher was motivated to investigate human and biological aspects of life in the Enkanini community from an ecosystems perspective. Courses completed during the researcher's Postgraduate Diploma studies in Sustainable Development awakened her desire to combine and apply scientific knowledge to social aspects of sustainable development, poverty, equality and conservation. These courses also increased the researcher's interest in food systems, food insecurity and food production, and she is especially interested in how these aspects play out in marginal urban areas. Furthermore, the researcher grew up gardening and practising permaculture at home, and has a particular interest in how households can supplement their diets, improve local soil quality and produce their own food cheaply, using locally available tools and materials.

The researcher's interest in local materials lead to another motivation for the research – the exploration of how solutions to daily household problems can be formulated using locally available resources and materials. To do this, the researcher recognises and demonstrates that 'people's ability to plan and implement innovative and practical solutions to the challenges they face (needs

to) ... be ... given the support that it deserves' (Royden-Turner, 2010:75). Although this research evolved over the course of the year since its inception, the researcher's principal vision for undertaking the research was to reconcile her background in the biological sciences with the urgent need to address informality, services provision and under-, over- and malnutrition in informal settlements.

4. Key concepts in thesis

- Closed-loop metabolisms – methods for using materials which move away from linear systems (typical of conventional product designs and value chains). These methods follow processes that are circular and more integrated, similar to those in nature (see Seuring, 2004; Smith, Vob & Grin, 2010). In this way, the nutrients, energy or resources from one part of a system can be re-used to contribute to generating products useful in other processes. This idea of circular product design has been described as being 'cradle to cradle' thinking, as opposed to the conventional 'cradle to grave' designs typical of linear systems (see McDonough & Braungart, 2002).
- Co-production – this is a widely debated term. In general, it refers to '... a strategy used by citizens and the state to extend access to basic services with relatively little consideration given to its wider political ramifications' (Mitlin, 2008:339). Co-production methods are used by social organisations and citizen groups '... to secure effective relations with state institutions that address both immediate basic needs and enable them to negotiate for greater benefits' (Mitlin, 2008:339).
- Food loss – this is 'the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption' (Gustavsson, Cederberg, Sonesson, van Otterdijk & Meybeck, 2011:2). These decreases can happen, for example, at the stages of processing, production, or post-harvesting (Parfitt, Barthel & Macnaughton, 2010).
- Food waste – food waste is where losses of food occur at the end of the supply chain – i.e. in the consumption and retail phases (Parfitt et al., 2010). In this thesis, however, the kind of food waste that is focussed on is food that is thrown away by the consumer during or after the preparation of food (i.e. kitchen scraps).
- Food wastage – a term used to describe a combination of both food waste and food loss, as it can include any food that is lost to waste (see description in preceding point) or deterioration (rotting or spoiling) (FAO, 2013a).
- Incrementalism – gradual changes or improvements to infrastructure, behaviour or social networks and institutions.
- Informal Settlement – an area where people live that is '... characteri(s)ed by inadequate housing conditions; deficient urban services (water supply, sanitation, drainage, solid waste disposal, and roads and footpaths); unsanitary and dehumani(s)ing living conditions;

extremely high densities (of both people and dwellings); and, frequently, long travel distances to job opportunities' (Majale, 2008:271).

- iShack – improved shack (ecologically designed shack with solar domestic energy system – see Keller, 2012).
- Informal Settlement Upgrading (ISU) – for some practitioners and politicians, this consists of actions that improve slum dwellers' environments from a physical perspective (Keller, 2012). Expanding on this, others understand the concept as being '... any activity that brings about a net improvement to the wellbeing' of informal settlement residents (Keller, 2012:8). This can be done in many ways, one of which includes building the capabilities of those involved (Keller, 2012).
- In situ – a situation where an activity occurs concurrently with the continuation of everyday household living activities, or where an activity is carried out in the exact location where it is needed.
- In situ resource recycling – the re-use of useful materials such as food waste and other organic matter carried out in the area where the materials actually originate, and while households continue need or generate them.
- Participatory Action Research (PAR) - the closest approximation for a definition of PAR as it is understood and interpreted in this research comes from Reason and Bradbury (2001; cited in Krumer-Nevo, 2009:280) who describe PAR to be a kind of 'participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview.' In this thesis, the participatory nature of the research is closely related to the 'voice' of Enkanini's human and non-human residents (see explanation for 'voice' in the last point in this section).
- Slum – term used interchangeably with Informal Settlement.
- Transdisciplinarity – Transdisciplinary science has been described as being work which arises from 'cognitive and social co-operation across disciplines' with the intention of applying scientific knowledge directly in 'political decision-making and societal problem-solving' (Burger & Kamber, 2003:44). In addition, transdisciplinary work involves 'participation of non-scientific stakeholders in the process (of transdisciplinary activities and research)' (Burger & Kamber, 2003:44. Transdisciplinarity requires working with 'relevant, complex problems' and in this way, using this method has 'the potential to contribute to sustainable development' (Scholz, Mieg & Oswald, 2000:479). Transdisciplinarity is therefore characterised by mutual learning between those involved, and where research is aimed at working on complex societal problems (Scholz et al., 2000). Transdisciplinarity has sometimes been called in vivo or real life knowledge (Marais, 2011). Its aim '... is to not only understand the world, but also to find solutions to the complex problems facing us all today, including having to change the systems of reference which produce these problems

...’ (Nicolescu, 2006:158). Transdisciplinary work involves investigating what is between disciplines, what is across the disciplines, and what is beyond them (Nicolescu, 2006).

- Voice – in this thesis, this word refers to ideas and opinions held strongly or in common amongst informal settlement residents, particularly those opinions related to service delivery. The word is also used, perhaps in a more abstract way, to represent the collective characteristics, trends or struggles of biological elements in environments where informal settlements are located.

5. Research context

a. Transdisciplinarity and real-life context setting of research

The researcher was a member of the transdisciplinary group of researchers in the Transitions Collective. Transdisciplinarity is the main theoretical and methodological approach used in the Collective’s work. The group works on emulating this integration of different disciplines, as it involves university professors and researchers working together with practitioners and specialists such as engineers and municipal employees, as well as with Enkanini residents themselves.

Transdisciplinary research is both urgent and necessary, as it is a way of investigating and simultaneously responding to real-life and complex problems that are socially relevant to communities experiencing these problems. The context of the case study for this thesis lends itself well to transdisciplinary theory and methodology. This is because the institutional, social, health, environmental and economic issues linked to management of household food waste in informal settlements such as Enkanini, involve a large number of elements (both human and non-human), which interact in complex and changing ways. Furthermore, solid waste management is a challenge which both the authorities in Stellenbosch Municipality and the region’s residents need to address with increasing urgency and in ways that are more holistic, sustainable and just.

The Collective researchers seek to understand problems, including their complexity, and the range of ways these problems are perceived both from real-life and scientific perspectives. These researchers also carry out case studies which assist in linking abstract and case-specific knowledge, which is another characteristic of transdisciplinary work. All of these aspects of research and activities being carried out in Enkanini, including the case study for this thesis, are aimed at increasing and building knowledge and practices which contribute to how we understand a community’s common good and well-being. Aspects and limitations of transdisciplinarity are described and discussed in more detail in the methodology section in Chapter 3.

b. Informal Settlement Upgrading Group research - previous food waste studies

In line with the transdisciplinary nature of the Collective's approach to research, the focus of this research is not on 'a particular physical construction' – such as waste management service delivery (Swilling *et al.*, 2013:15). Instead, this research seeks to answer more deeply rooted questions such as how 'active (social) networks' of residents in a community can create the knowledge they need in order to generate solutions that are in line with their own conditions and contexts (Swilling *et al.*, 2013:15).

The potential and safety of recycling of food waste has not yet been investigated in any detail in Enkanini. However, some vegetable planting and food waste composting activities were carried out by Vanessa von der Heyde and co-researchers in the food waste pilot project of 2012, using the food waste collected at that time. This researcher builds on the platform provided by von der Heyde's work, and also introduces new lines of investigation. These new directions include biological investigation into the conditions and safety of composting opportunities, as well as the exploration of safe and creative artistic spaces for learning and representing community participation, in addition to generating wider interest in food waste management around Enkanini.

Figure 1 indicates the similarities, links and differences between the 2012 food waste collection pilot project, and the 2013 food waste collections associated with the case study for this thesis.

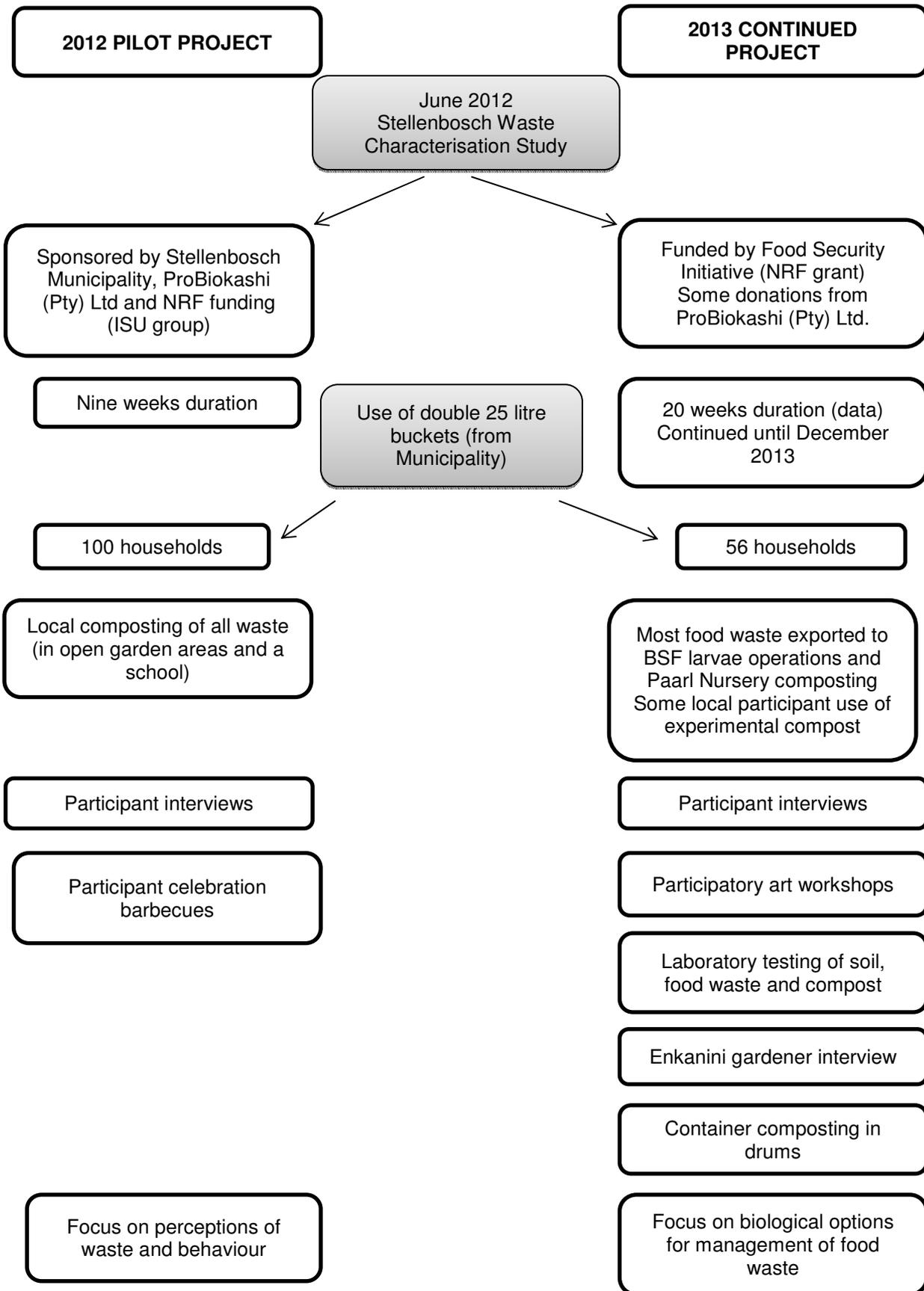


Figure 1: Representation of similarities, links and differences between von der Heyde’s 2012 pilot project and this case study (Source: Author, 2013)

c. Focussing the research topic

While food (in)security is well-researched in general, there appears to be little attention paid to food waste and its relationship to food insecurity. Issues relating to food waste are consistently overlooked in the discourses of poverty, service provision, food security and waste management. Literature relating to local food systems and production does not often make the link between the recycling of food waste and making food systems and resource flows more efficient and ecologically sustainable. This presents a unique opportunity to explore poverty, food waste and livelihoods through an ecosystems lens, in the real-life context of an informal settlement in South Africa. Other gaps in research and activities by universities, NGO's and government (regionally and internationally) include aspects of what *in situ* and incremental upgrading of waste management services means at a low-technology and grassroots level.

6. Research problem

The basis of this research is the idea that there is a need for recognising the value of food waste and its potential as a resource, and its relevance for *in situ* composting and nutrient recycling. Viewing sustainable food waste management in the broader context of urban areas reveals its numerous benefits. Diverting food waste from landfill saves landfill space, and reduces the overall volume of domestic waste which municipalities have to collect and of which they have to dispose. This is possible if diversion is done by households and other entities such as businesses and institutions. This kind of diversion saves municipalities money, mostly by extending landfills' lifetimes, thereby reducing the frequency that new ones need to be constructed. In addition, food waste contains nutrients which can be recycled into compost and re-used for food production – whether directly as compost for crops, or indirectly as a food source for other organisms which become food sources themselves. Furthermore, separation of food waste at source increases the recyclability (potential for recycling) of other non-food waste materials such as plastics, paper and cardboard. This is because, in practical terms, these materials are less likely to be contaminated because they are not in contact with food or other waste. Finally, if separation of food waste at source is done correctly and efficiently, the volumes and weights of waste that municipalities need to transport can be substantially reduced. This saves them time, effort and money needed for waste collection services, vehicles, logistics and infrastructure.

Municipalities value and rely on (social, biological and economic) data to assist them in building cases for directing decision-making processes. To this end, data can also help them change their 'business as usual' models of operation. In this thesis a case study is provided which presents the scientific (biological and ecological) and social context of this kind of data, as well as a framework on which future waste management initiatives can be based in the Stellenbosch Municipality and elsewhere.

Given Enkanini's difficult topography, together with organisational and logistical obstacles within the municipality regarding the organisation and carrying out of waste collections from the area, domestic waste often sits festering in open skips in the settlement for days or weeks. This putrefying waste becomes problematic because it attracts dogs, vermin (such as rats), flies and other pests. These pests can become even more of a problem because they can spread diseases and germs, especially to children who play nearby or to people scavenging for useful recyclable scraps (such as plastic, metal and cardboard) from which they can earn money. Separating organic waste (i.e. the primary reason for vermin attraction) from household rubbish and removing it completely from the waste stream in Enkanini can thus contribute to reducing the indirect but significant problems and dangers associated with open rotting waste and human and animal contact with vermin.

7. Research objectives and questions

The research objectives described below are combined and used to guide the research for this thesis, in order to formulate the main research question.

a. Research objectives

The objectives of this research are to:

- investigate how or whether waste management strategies based on the recycling of food waste could assist in closing resource loops in Enkanini;
- explore ideas to test how or whether natural processes can be copied or used to assist in managing food waste in Enkanini;
- investigate methods for incrementally improving current waste management strategies in Enkanini which are based on biological processes that are space efficient;
- develop an understanding of some of the potential limitations of or barriers to food production (Urban Agriculture) in Enkanini; and
- develop an understanding of the value (social, educational, ecological) of food waste in Enkanini and how this could be improved.

b. Main research question

In order to address the research objectives, a number of research questions were devised. The main question which the researcher seeks to investigate is:

How can incremental *in situ* improvements in organic waste management strategies support closing the food waste loop in Enkanini?

c. Guiding sub questions supporting main question

In order to tackle the main research question, several sub-questions were addressed in this research. The most pertinent of these questions relate to the subject of informal settlement upgrading or 'incrementalism'. In literature and practice, this incremental approach to improvement of services in settlements typically focuses on improvements in physical infrastructure and services, such as in those of housing and sanitation. However, there is little consideration of what incremental improvements in solid waste management (and infrastructure) would look like in informal settlements. Therefore, one of the main guiding questions for addressing the primary research question is:

- What could real incremental improvements in waste management look like on the ground for Enkanini residents?

Other questions which help to inform an understanding of what these kinds of improvements could mean in the settlement of Enkanini include:

- What can be done to increase the potential social, ecological and educational value of food waste recycling in Enkanini?
- What are the main social and physical barriers, limitations or challenges to food waste management and food waste recycling in Enkanini?
- Can we harness ecosystem services in a limited space (such as composting of food waste in containers)?
- How can we mimic nature's recycling processes incrementally in an informal and cramped environment?

8. Significance of the study

Issues of service provision, housing delivery and waste management have been described as 'red flag' issues for Stellenbosch (Marais, 2011:7). The Enkanini settlement is a local example of how these issues are both a major challenge but also an opportunity for dialogue and action for both the municipality and Enkanini residents. This requires skilled facilitation and collaboration among and across many different areas and disciplines. In order for us to better comprehend the challenges related to infrastructure improvements in slums from a transdisciplinary approach, we need to look at these problems from 'multiple perspectives and at multiple levels' (Swilling *et al.*, 2013:13). Transdisciplinary research initiatives in Enkanini have primarily been about technical innovations related to services. However, the social complexity and context in which these technical innovations are embedded means that seemingly simple innovations can actually become the primary 'basis for formation of networks and social organi(s)ation' (Swilling *et al.*, 2013:15). Organisations in poor urban populations must have access to knowledge networks that help them with the 'complex processes of innovation (for upgrading services)' (Swilling *et al.*, 2013:10). Generally, most research is done in order to extract scientific facts or data from an area or

situation, instead of to co-produce knowledge that is useful in the social context of the urban poor (Swilling *et al.*, 2013). However, transdisciplinary research can play a role in filling this gap (Swilling *et al.*, 2013).

Recognising that ‘... poverty is not only experienced, but responded to’, (Battersby, 2011a:29), this research explores how Enkanini’s residents are able to do this on a daily basis in relation to how they use, access and dispose of household food. The research provides a basis for assessing the potential for households to contribute to their own food needs through food production from *in situ* recycling of food waste (via composting).

The practical activities being carried out by researchers of the Collective, together with residents in Enkanini, allow for new and surprising interactions from which both researchers and residents can learn. Also, the formation of groups that have some co-ordination of ‘micro-actions to achieve shared benefits’ could have results that are wide-reaching or that have a larger-scale significance (Swilling *et al.*, 2013:10). These results include the increasing trend that ‘community driven development has become the World Bank’s fastest growing strategy for delivering development assistance’ (Dasgupta & Beard, 2007:229). The co-production of socially useful knowledge is an outcome of transdisciplinary research because researchers and participants share learning experiences, the results of which are useful for informing future activities, research, enterprise and business stimulation and government investment.

9. Thesis outline

This thesis begins by describing the service provision challenges in Enkanini and sets this in the context of other challenges the Stellenbosch Municipality faces, namely space in the landfill for solid waste disposal. An approach to Informal Settlement Upgrading is proposed which focuses on incrementally improving services, in this case, services relating to food waste management have been chosen. After a brief preliminary literature review which provides the context and focuses the research direction, some research objectives and questions are developed. The main literature review is then presented, to assist in the identification of gaps and opportunities for consideration relating to informal settlements, urban agriculture, nutrition and closed-loop food waste management.

The foundational methodology used in this thesis, that of transdisciplinarity, is described and explored in the literature review and methodology sections. The flexible and recursive nature of the literature review and data collection processes are described, and are explained to be shaped this way as responses to the constantly changing and unpredictable case study environment. The kinds of data collected in the thesis are described and detailed, and the methods used to collect these data are elaborated upon.

The thesis then goes on to describe the methodology for the practical activities that were carried out for the composting and food waste collection experiments in the case study, as well as the materials that were needed for this work. A brief description of the events leading up to this research from a previous pilot study (and some of the characteristics thereof) is given. The potential limitations of this case study are considered and described, and aspects relating to the originality of the research are explored. Results from all laboratory testing and food waste collection participant surveys are quantified, compared, categorised and summarised. The social and participatory aspects of this research are described and interpreted with reference to social learning theory. These results are then discussed, referring to previous or similar studies where relevant.

Results from participant surveys and food waste collection data and laboratory testing are interpreted and highlighted in the conclusion, and a phased action plan for scaling up the project activities is presented. In this study, emphasis is placed on the importance of minimising bacterial growth risks associated with food waste, as well as on the importance of and need for training of local residents related to the value-adding and technological aspects of different waste management options. This case study illustrates these actions are critical, before any activities relating to service upgrading of this nature can be scaled-up.

Chapter 2: Literature review

“The real voyage of discovery consists not in seeking new landscapes, but in having new eyes.”

Marcel Proust

1. Introduction

In this literature review, challenges of food waste management, housing and service delivery in South Africa are described. This is the background for an explanation and justification for Informal Settlement Upgrading (ISU) and how this relates to daily domestic solid waste management challenges of residents in these areas. It explains how ISU can be done by residents, government, private business and non-government organisations *in situ* i.e. in the places where residents actually live, and more importantly, *while* they are living there. These approaches are then challenged and advanced by exploring whether ISU thinking can be applied to food waste management, organic resource and nutrient recycling and food production in informal settlements of Southern Africa, where food insecurity is arguably felt most acutely.

The review explores the benefits, limitations and shortcomings of policy-driven Urban Agriculture (UA) in Southern and South Africa working on targets of poverty alleviation and food security. It describes the various dynamics that exist between urban poverty, food insecurity and South Africa’s social safety nets (government grants) in particular. It illustrates how these seemingly well-structured mechanisms can sometimes be counter-productive both in their objectives and consequences.

Details, descriptions and complexities of regional and local urban food insecurity are explained. In addition, this review provides an introduction to statistics and practices relating to food waste both nationally and internationally. The legal conditions that will soon be applicable to organic waste generated in South Africa are briefly described.

Next, ways of interpreting, understanding and applying different forms of Social Learning (SL) concepts and theories to UA and food systems are explored. These interpretations are useful for considering how they can be applied more widely to behaviour change (especially relating to localised waste management and food production in communities), with an ultimate goal of contributing to greater overall food system sustainability.

A brief description of major and critical food production limiting factors in informal settlements such as available space and land tenure is given. Through these explorations, the researcher indicates

that soil and compost emerge as potential starting points for unpacking a socio-ecological investigation of the limits and failures of UA, food access and community food waste management in informal settlements. This sets the scene for the thesis, which is based on a case study exploring these ideas relating to 'Ecological Food Sense' in the context of Enkanini in Stellenbosch, South Africa. Enkanini is a poorly-serviced illegal and informal settlement in the Western Cape of South Africa where very little local and *in situ* food production currently exists, and where little to no recycling of food waste is being done.

The characteristics of harnessing an organic waste resource - specifically household food waste - are explored in this review, in relation to how this could enable closing the loop of community resource cycles. Interacting more sustainably and efficiently by mimicking ecological processes (or copying natural processes) within the socio-ecological system is suggested as an area of investigation. Options for intercepting the waste stream in this way include recycling food waste (directly or indirectly) into compost or other useful inputs into the food system. These options are considered within the real-life context of an informal settlement environment in South Africa.

Complexity, systems thinking and ecosystem perspectives are shown to be useful lenses through which we can conceptualise and tackle food waste management, health, nutrition, quality of life and service delivery challenges in informal settlements. Looking through the lenses of complexity and ecosystems encourages new ways of thinking about food waste management that enhance the socio-ecological sustainability of the daily interactions of residents of informal settlements. This perspective also offers new ways of interpreting how community members interact, how they access and use food, as well as how they relate to or perceive food waste. One of the tools for enabling this kind of 'research activism' involves the co-creation or generation of knowledge with communities. In particular, the urgency of the need for this kind of work for food systems is highlighted.

2. A hungry world

a. Failure to meet an on-going challenge

The United Nations (UN) bravely announced poor performance in a number of its Millennium Development Goals (MDG's) in its most recent report on these goals (UN, 2012). These admissions include that 'hunger remains a global challenge' (UN, 2012:5). According to latest figures, around 870 million people were estimated to be undernourished in the period of 2010 – 2012 (IFAD, FAO & WFP, 2012:8). Most of the world's undernourished population lives in developing countries - about 852 million of these 870 million (IFAD, FAO & WFP, 2012:8). This figure represents about 14,9% of the population in these countries (IFAD, FAO & WFP, 2012:8). In 2009, the FAO estimated about 1 billion people did not have adequate access to protein- and energy-rich food (FAO, 2009; in Crush, Frayne & McLachlan, 2011). All these statistics come as

heavy blows, as there have, in fact, been measured global improvements in income poverty levels (UN, 2012:5).

b. Hunger in Africa and South Africa

In 2010, it was estimated that the number of undernourished people in Sub-Saharan Africa was 239 million (FAO, 2010:5). These figures meant that Sub-Saharan Africa had the highest proportion of undernourished people in the world, at 30% of its entire population (FAO, 2010:5). Comparing changes in undernourished populations in the period of 1990 – 1992 and 2010 – 2012, the percentage of the Sub-Saharan population that was undernourished actually increased from 17% to 27% (IFAD, FAO & WFP, 2012:9). The region also has the highest degree of poverty in the world (UN Habitat, 2010a:xiii). Furthermore, Southern Africa has the highest degrees of socio-economic inequality, and extreme poverty is present ‘along class and racial lines’ (UN Habitat, 2010b:14).

Superficially, South Africa may be perceived to be an exception to the Sub-Saharan Africa undernourishment statistics, as it is formally classified as being food secure when measured according to aggregate food availability (Drimie & McLachlan, 2013). However, delving deeper into this data reveals some telling and worrying statistics. In the National Food Consumption Survey (NFCS) of 2005, it was found that an alarming 51,6% of the South African population risked hunger (Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie *et al.*, 2008:259). In addition, stunting was found to occur in almost one in five children in the same survey (Labadarios *et al.*, 2008:257). In particular, children between the ages of one and three were found to be most affected by stunting, and interestingly, most especially those living on commercial farms in the country (Labadarios *et al.*, 2008:253). However, it was found that levels of stunting had improved slightly in children between the ages of one and nine years old in the 2005 NFCS compared to those in the 1999 NFCS (Labadarios *et al.*, 2008:267).

c. Inter-connected crises

The global financial crisis of 2008 and the similarly timed fuel price crisis culminated in the compounding of negative effects of a variety of structural and environmental factors, which in turn provoked the global food price crisis. These factors included ‘... the combined effects of competition for cropland from the growth in biofuels, low cereal stocks, high oil prices, speculation in food markets and extreme weather events’ (Nellemann, MacDevette, Manders, Eickhout, Svihus, Prins & Kaltenborn, 2009:11). The quick succession of these crises, as well as the depth and breadth of their impacts indicate they are entangled in a complex web of dynamically interacting socio-economic and ecological elements.

The food crisis has caused increases in major commodity prices by several multiples (Nellemann *et al.*, 2009). However, it can be argued that the fuel crisis is the major driver behind these changes. The global nature of these commodity prices makes them volatile, which means the global poor are left vulnerable to price shocks. This relationship is explained by Fan, Torero and Headey (2011:2), who point out that extreme food price volatility is 'particularly harmful for the world's poorest consumers ... (who) have limited capacity to adjust quickly to rapid price increases'. Both international and national policy responses to skyrocketing food price increases in 2007 and part of 2008 did almost nothing to deal with the 'very serious impacts (of these increases) on low-income urban dwellers' (Cohen & Garrett, 2010:467). Consequently, the food crisis has also 'driven 110 million people into poverty and added 44 million more to the already undernourished' (Nellemann *et al.*, 2009:11).

Even before these multiple crises of 2008, Southern Africa was reeling in the clutch of a desperate and protracted food crisis. Back in 2002, it was estimated that there were over 15 million people who needed food aid in the region because of the failure of their livelihood systems (UNOCHA, 2002; in Drimie & McLachlan, 2013:2). Further to this, Drimie and McLachlan (2013:1) point out that the changing global context means that, '... solutions (for food insecurity) that may have worked a decade ago are no longer adequate'. To illustrate this complexity, in a study done on four Sub-Saharan countries (Uganda, Ghana, Nigeria and Mozambique), it was found that policy statements related to the complexities of the food system such as nutrition and food security did not 'feature prominently in setting the scope and scale of government action or in allocating public resources to address undernutrition' (Benson, 2008:73). Benson (2008) also found that in these four countries, efforts for combatting undernutrition were not effectively co-ordinated or sequenced to make sure that all elements necessary for addressing the issues were put into place.

d. Going hungry in an increasingly urban world

Coupled with global obstacles and complications to food security is the fact that in 2008, for the first time in human history, the world became more urban than rural - it was predicted that more than half of the population at the time (about 3.3 billion people) would live in urban areas (UNFPA, 2007:1). And so, in our various ways, we are now coming to terms with the fact that our world 'is inexorably becoming urban' (UN Habitat 2010a:vii). This urbanisation trend is set to continue - by 2030 there will be higher urban than rural populations in all developing areas of the world (UN Habitat, 2010a:vii). Furthermore, many of these 'new urbanites' around the world will be poor (UNFPA, 2007:1).

Africa is no exception to these urbanisation statistics. By 2009, the total population of Africa reached just over 1 billion (UN Habitat, 2010b:1). Almost 40% of this population lived in urban areas (UN Habitat, 2010b:1). It is predicted that by about 2030, Africa will be 50% urban (UN

Habitat, 2010b:1). To conceptualise this, if one puts the accumulated urban growth of Asia and Africa together for their whole history, this figure will be duplicated within just a single generation (UNFPA, 2007). This increasing urbanisation is encouraging a shift to life based on a cash economy, which is fundamentally changing the way we access commodities and resources, and in particular, how we source and access our food. As more poor people move to urban areas, our tradition of practising and relying upon small-scale and subsistence agriculture is being lost.

However, the urbanisation of Africa should 'not necessarily be seen as problematic' (UN Habitat, 2010b:2). In order to understand this perspective, we need to realise that the sustainability challenge calls for us to focus on cities so that they are 'people-centred concentrations of opportunity' (UN Habitat, 2010b:2). This requires that we acknowledge that when urbanisation occurs together with poor economic growth, or when redistributive policies are not effective or do not exist, poor people become more locally concentrated, instead of a reduction of poverty being achieved (UN Habitat, 2010a:x). Also, the lack of co-ordination within or between policies in local and national government limits the abilities of cities 'to meet the requirements of urban development and to deploy strategies that mitigate spatial inequality' (UN Habitat, 2010a:xiii).

e. Urbanisation in South Africa

Urbanisation statistics in South Africa are higher than those for the African continent. By 2001, about 56,2% of the population already lived in cities, with these rates predicted to increase to about 70% by 2025 (McLachlan & Thorne, 2009:9). In the Living Conditions Survey of 2008/2009, it was found that 67,9% of households in South Africa were in urban areas (Statistics South Africa, 2013:9).

3. Slums, Housing and Informal Settlements

a. The global challenge of slums

Although the proportion of urban populations living in slums (informal settlements) around the world has decreased, the absolute numbers of people living in these areas have increased (UN, 2012). This figure has been estimated to be about 863 million people (UN, 2012:5). By 2020, the worldwide slum dweller population is predicted to be 889 million (UN Habitat, 2010a:xii). This suggests that efforts to reduce the numbers of slum dwellers are 'neither satisfactory nor adequate' (UN Habitat, 2010a:xii).

Bettering the lives of slum dwellers in all developing regions requires programmes at the macro-level, which include improved water and sanitation, housing infrastructure and finance, and adequate living spaces (UN Habitat, 2010a:x). It has been stated that if we can improve lives of slum dwellers, this will be the most effective way of achieving all of the Millennium Development Goals (UN Habitat, 2010a:xii).

b. Slums in Sub-Saharan Africa

Sub-Saharan Africa has the highest prevalence of populations living in slums in urban areas in the world (UN Habitat, 2010a:xiii). Informal settlements are usually located within or next to urban areas and major cities (Misselhorn, 2008). These informal housing spaces work as vital 'holding places' for poor urban residents to access '... the urban environment at extremely low financial cost ...' (Misselhorn, 2008:5). This 'urban environment' represents an array of attractions - jobs, money, social life, food, commodities and all the other trappings of city life. It could be argued that being able to access the city and urban spaces can help poor residents to '... piece together various livelihood strategies ...' (Misselhorn, 2008:5). On the other hand, the effects of increasing urbanisation are often not positive in the short to medium-term. To this end, it is only when informal settlements become more formally recognised, and when formal services arrive at these settlements that improvements in living conditions and quality of life really occur. In short, whatever solutions we come up with, they will have to be urban.

c. Responding to challenges in informal settlements

Informality has been referred to as a 'practice of infiltration within the formal framework' (Dovey, 2012:352). This kind of infiltration and progression is what Bayat (1997; cited in Dovey, 2012:352) describes as being the 'quiet encroachment of the ordinary'. These frameworks can vary, for example they can be in urban planning and design, in infrastructure, in architecture, and in trade. Therefore, when we think of informality, we need to remember that it refers to any practices that 'operate outside the control of the state' (Dovey, 2012:352).

The multiple pressures acting on government to fulfil housing and service delivery targets which are promised each year in South Africa often results in hasty and poorly thought-out or designed responses dealing with these targets. These responses are often 'built upon a denial' of the fact that these settlements are likely to exist for a long time, and so are '... a rejection of the status of hundreds of thousands who reside in informal settlements ...' (Misselhorn, 2008:36). This also represents the shattering of the fragile form of democracy that South Africans have been cobbling together since the country's first democratic elections in 1994.

Responses to the various challenges and issues in informal settlements must be designed carefully to take into account the dynamics and nature of these settlements, so that they are suited to each context (Misselhorn, 2008). Indeed it is now becoming apparent that informal settlements are '... functionally integrated parts of many cities' and further that this informality cannot be removed through simply relocating it elsewhere (Dovey, 2012: 349). Most importantly, it should be remembered that when residents are relocated or removed from informal settlements, the social networks that make up the threads of the fragile fabric of life in these areas are destroyed.

The causes of the frequent and sometimes violent eruptions of anger amongst informal settlement residents are not only attributable to poor housing and service delivery (Misselhorn, 2008). They are also connected to the negativity, inferiority and stigma surrounding words used to describe them or with which they are associated (Misselhorn, 2008). These words include 'slum clearance', 'informal' and residents being given 'shack' statuses (Misselhorn, 2008:3). The use of these kinds of words causes the perception that these informal settlements (and therefore their residents) are 'like some kind of scourge' (Misselhorn, 2008:3). Being labelled in these ways compounds the negativity surrounding language used when discussing aspects of informal settlements. These labels can sometimes even undermine and devalue the most well-thought-out or well-intended poverty reduction interventions.

d. Informal Settlement Upgrading (ISU)

The concept of Informal Settlement Upgrading (ISU) refers to the improvement of existing dwellings and service infrastructure in informal settlements. This is often in contrast to traditional methods of dealing with slums, where they are simply demolished and where residents are relocated to new housing areas – if they are lucky.

ISU is also a more constructive and pro-active response to traditional mechanisms in what we know as the 'paternalistic development approach' (Huchzermeyer, 2006:50). To this end, most subsidised housing which has been built in South Africa since 1994 has generally been 'project-linked' and 'contractor-driven' (Huchzermeyer, 2006:50). This traditional top-down approach unfortunately encourages residents of informal settlements to do what has been termed 'sit back and wait' for service and housing delivery by government (Huchzermeyer, 2006:50)

Upgrading can be carried out either by residents saving up money and working and building individually, or by residents who mobilise themselves into working groups and saving schemes. Work is also done by Non-Governmental Organisations (NGO's) and government, or through a combination of inputs from all these players. Understandably, due to the very complex, tense and ever-changing relationships between residents and government, the undertaking of ISU is 'without doubt a challenging and complex task ...' (Misselhorn, 2008:10).

When ISU is done in progressive steps (such as according to budgetary allowances of residents and organisations), these gradual improvements are called *incremental* upgrades, which are also done *in situ* (i.e. in the actual location of the existing informal settlement, and while residents continue to live in these locations). Sometimes these small upgrades are the only improvements in housing and services residents in these areas experience or are able to carry out in their entire lifetimes.

However, it would be naïve to presume that ISU always occurs in one direction, following these progressive steps on an upward direction. The overall improvements and upgrades, while always being fundamental goals in the steps toward incrementalism, do not always guarantee success at each and every step along the way. Indeed, the complexity and risk of living in informal settlements presents numerous challenges to implementing ISU. This is because residents of informal settlements exist in fairly volatile situations and living conditions (e.g. seasonal or ad-hoc employment, changing family structures, insecure land tenure, fire risks and threats of crime or violence). Thus, residents' ever-changing situations mean that their abilities to contribute to and participate in ISU activities are dynamic and often unpredictable.

e. Upgrading food waste management, soil conditions and food access in informal settlements

The challenge of improving and upgrading services in informal settlements is also an opportunity to incorporate '... food security as a guiding design and development principle' (Frayne, Battersby-Lennard, Fincham & Haysom, 2009:33). It is an invitation to see how incrementally improving informal settlement residents' living conditions can be done in conjunction with increasing local and *in situ* household food waste management. This could be done through activities such as community food waste collections and composting. The use of compost *in situ* can contribute to local food production, assuming this compost contains adequate nutrients and minerals. Recycling food waste locally provides an opportunity to increase the efficiency of resource recycling and maintain resources (nutrients and energy) within the community. Also, growing food locally and *in situ* can facilitate residents' access to fresh produce and reduce the stress of on-going food insecurity and difficulties of accessing food.

Pieterse's 'radical incrementalism' concept (2008; cited in Royden-Turner, 2010:75) is particularly interesting as a perspective for informing the incremental aspects of this research. This kind of incrementalism refers to 'multiple small revolutions' that Pieterse suggests we can carry out to change the way we interact and live (Pieterse, 2008; cited in Royden Turner, 2010:75). These small revolutions can, '... over time ... change the notions of what is considered possible' (Royden-Turner, 2010:75). The questions this perspective raise in this research context are:

- What do these many small revolutionary steps look like in practical terms for food waste management in an informal settlement?
- How can these small steps be applied in the small-space context of an informal settlement such as Enkanini?

Thinking about these small revolutions also raises questions about the existence of or potential for another kind of informal and incremental 'social' upgrading. In other words, what does incremental

upgrading of willingness, community participation, cohesion and co-design of innovations look like in an informal settlement? What do these small steps look like practically in terms of their contribution to an improved sense of community and of living conditions of residents in informal settlements? These kinds of questions can be investigated by setting up a communal activity, such as food waste collections.

4. Urban food security

a. Urban Food security, sustainable diets and sustainable development in South Africa

The concept of sustainable development first emerged as being one of global interest when it was described by the World Commission for Environment and Development (WCED) in 1987 as being:

‘... development that meets the needs of present generations without compromising the ability of future generations to meet their own needs’ (WCED, 1987:37).

This definition has been and continues to be widely-challenged, most significantly because of its lack of clarity and explicit explanation of what ‘development’ and ‘needs’ might mean, let alone to whom this development and these needs might refer.

Similarly, one of the broadest, but perhaps also the most widely-contested definitions of food security is:

‘... when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life’ (World Food Summit, 1996; cited in FAO, 2010:8).

As was the case for the WCED definition of sustainable development, the opaqueness of this definition of food security has led to its being considered a ‘nebulous term’, due to the complex relationships between food access, availability and use (Ruysenaar, 2013:5).

A recent and perhaps more constructive and useful marriage of the WCED’s definition of sustainable development with that for food security described at the World Food Summit in 1996 is the concept of sustainable diets, suggested by the FAO (2009). Sustainable diets are ‘good for humans and the eco-sphere both in the present and the long term’ (FAO, 2009:6). Characteristics of such diets include that they are ‘biodiversity-promoting’, and are able to meet nutrient needs while also ‘conserving and promoting sustainable ecosystems and human wellbeing’ and ‘respecting environment carrying capacity’ (FAO, 2009:6).

Interpreting food security in the local context, South Africa has developed an Integrated Food Security Strategy (IFSS), where food security is described as being:

‘... physical, social and economic access to sufficient, safe and nutritious food by all South African (sic) at all times to meet dietary (needs) and food preferences for an active and healthy life’ (National Department of Agriculture, 2002:15).

Although the IFSS definition is similar to the (dated) one described at the World Food Summit back in 1996, McLachlan and Thorne (2009:5) consider it to be adequate enough to ‘guide analysis and action at all levels’.

b. Urban Food Security and the Cash Economy

As a result of the complexities of food security described thus far, urban food security is becoming more widely acknowledged as a key developmental challenge of the 21st Century (Crush & Frayne, 2010; Battersby, 2012). For many people in urban areas, accessing food and feeding their families is extremely difficult. For poor urban families, the future looks particularly grim – food access for these families is becoming increasingly challenging. Food security affects marginalised populations in both rural and urban areas, and accessing basic adequate nutrition remains a crippling, daily challenge for millions.

For poor populations living in urban areas, the cash economy dominates over their access to basic needs such as food (Armar-Klimesu, 1999). For this reason, urban food systems are linked to both vulnerability to food insecurity and poverty (Armar-Klimesu, 1999). In fact it is this precise ability of these populations to earn cash incomes which is a major determinant of urban food security (Armar-Klimesu, 1999). Compounding these pressures is that, in the cash economy, the biggest challenge which urban residents face is that most of them actually work in sectors with low wages, or where work conditions and job tenure are insecure (Armar-Klimesu, 1999).

c. Mis-directed focus on agricultural production in rural areas

Ruysenaar (2013:2) described the South African government’s response to food insecurity as being ‘incoherent’. This is compounded by the fact that food insecurity is often viewed as being a rural problem (Crush & Frayne, 2010). However, shortages in food have been found to be less linked to local production problems and more to failures of people to actually access food (de Wit, 2009). This unbalanced rural focus means that food production in (and for) poor urban areas is forgotten. Also, the poorly placed focus means that a disproportionate amount of attention and pressure is put on both small-scale and commercial farmers in rural areas.

Rural and agricultural production bias is contributing to the emergence of an ‘invisible crisis’, which is the ‘silencing’ of the urban poor’s voice (Crush & Frayne, 2010:7). The scale and urgency of poor urban residents’ food security plight is being smothered by political, academic, institutional and organisational claims that food security is largely a rural and production problem. Indeed, we are warned that when prices of food increase rapidly, the general focus on agriculture as well as food insecurity in rural areas ‘misses a large part of the problem’ (Cohen & Garrett, 2010:468).

d. Food (in)security in low-income urban areas in South Africa

In South Africa, food security is part of the country’s rights-based constitution. The Constitution ensures the right to all people to access enough food (Government of South Africa, 1996). The high degree of hunger in South Africa is congruent with evidence that poverty levels in the country have also failed to improve significantly (McLachlan & Thorne, 2009). Indeed, it has been estimated that about 50 to 70% of the South African population live in poverty, which varies according to which poverty line values are used (McLachlan & Thorne, 2009:8).

Stretched budgets mean many families are forced to sacrifice the amount of food they buy, the kind of food they buy, or the number of meals they eat per day – all of which contribute to reduced access to vital nutrients. In the AFSUN Survey in Cape Town, it was found that much of the food that residents in the sampled areas (informal settlements and low income areas) obtain is sourced on a daily basis from the informal sector (Battersby, 2011b). These enterprises can include places such as spaza shops (small convenience shops) and stalls from street vendors in and around settlements, or along residents’ daily commuting routes. In addition, Battersby’s work (2011b) indicates that households which are more food insecure in Cape Town are more likely to rely on informal sources of food and the informal market in general.

As can be seen in the recent farm worker wage protests in the Cape Winelands, many low-income households in this part of the Western Cape rely on seasonal agricultural employment. Cohen and Garrett (2010:476) surmise that the motivation behind support that policy makers give to programmes for reducing the impact of food price increases on urban residents is primarily the idea that these programmes ‘pacify urban discontent’. Seasonal wages received by these agricultural labourers expose them and their families to periods when they have little money to spend on food. This time has been referred to as a ‘hungry season’ by Joubert (2012:91). The term hungry season was once only used in the agricultural world – describing the ‘... hollow months between when last season’s stores have been eaten up and this season’s crops are ready for harvest’ (Joubert, 2012:91). This concept has been transferred to urban thinking – referring not to harvests but rather to the time between ‘one pay cheque and the next’ (Joubert, 2012:91). For agricultural areas like Stellenbosch, these hungry seasons are periods when families experience decreased availability of food due to the seasonality of their incomes. Coping strategies employed

by families during hungry times include borrowing food (or money to buy food) or sharing meals. Although this behaviour is a heartening display of the power of *ubuntu*¹ typical of poorer communities in Southern Africa, it ‘obscures the failings in urban food systems’ (Frayne *et al.*, 2009:28).

5. Urban Agriculture

a. Agriculture in cities?

Urban and Peri-urban Agriculture (UPA) is agricultural activity that is practised in peri-urban fringes (or ‘green belts’) of towns and cities, or in built-up intra-urban areas (Thornton, 2008:243). It is important to note that this definition not only refers to food crops, but also to aquaculture (fish farming), horticulture, forestry and livestock rearing (Burger, Cloete, Geldenhuys & Marais, 2009). It must be noted that farming done by people living in urban areas should not automatically be assumed to be the same as urban agriculture (Foeken & Mwangi, 2000; in Burger *et al.*, 2009). This is because these residents might also carry out agricultural activities in rural areas where they grew up (Foeken & Mwangi, 2000; in Burger *et al.*, 2009). The terms Urban and Peri-urban Agriculture and Urban Agriculture appear to be used interchangeably in literature, and for simplicity in this thesis, these practices will be referred to as Urban Agriculture (UA).

The impact, role and kinds of UA practiced around the world vary quite significantly, both within and between countries (Hovorka, 2002). Over the years, UA seems to have built up a mixed reputation around the world, as evidence for it seems to be ‘scattered or speculative’ and it is accompanied by very little supporting data for general statements made on it (Hovorka, 2002:1). The practice of UA can often be seen as being a kind of ‘artefact of rural life’ which quite simply should not be a part of the city, and that it can pose health problems or threats to people living in urban areas (Hovorka, 2002:3).

b. Urban Agriculture and Food security

The practice of UA has been considered as an option for getting food to poorer parts of urban populations (Atkinson, 1995). One of the main cited advantages of UA is its potential to supply and produce cheap food for the urban poor, both by using skills of those residents recently relocated from rural areas, and through using waste land (Atkinson, 1995).

In the past, many were convinced that UA was a panacea solution to food security in the context of rapid urbanisation – there was a growing interest in its possibility for helping to solve future food supply issues (Binns & Lynch, 1998). UA had also attracted attention from international development agencies (Rogerson, 1998). International literature listed the overall benefits of UA to

¹Zulu word describing the feeling of togetherness, community, interconnectedness, and responsibility to each other

be 'enhancing food security' and providing employment and income for middle-income and poor urban residents in cities (Rogerson, 2003:132).

To this end, Armar-Klimesu (1999:104) points out that UA contributes 'in no small measure' to food security in large urban cities, as it forms an important part of the urban food system, as well as a way that vulnerable groups can reduce the problems they face associated with food insecurity. Armar-Klimesu (1999) claimed that the growth of food in cities could contribute to people's diets, especially those in low-income groups, through the provision of fresh vegetables and fruit. Pertinently, Armar-Klimesu (1999) reminds us that we need to be aware that food security includes not only quantity but quality of food. For this reason, the local production of food is a critical part of food security (because fresh foods can reach markets quickly), and that it needs to be seen as 'complementary rather than competitive' to the other systems of food supply in urban areas (Armar-Klimesu, 1999:106).

Interest in UA and its links to urban food security have continued since the 1990's. Indeed, the ability of UA to contribute to healthy nutrition and urban food security was more recently described as being 'its most important asset' (van Veenhuizen & Danso, 2007:41). This was because food production was (and continues to be) a way that the urban poor respond to their poor purchasing power and lack of reliable access to food (van Veenhuizen & Danso, 2007). This lack of income for the urban poor results in a reduction in the quality or quantity of food they eat, and apparently this is more so the case than in rural areas (van Veenhuizen & Danso, 2007).

In advocacy-driven support of UA, findings were that it started to show that 'households engaged in food production appeared to achieve greater food security and their nutritional status tended to be better than that of non-farming households' (Crush, Hovorka & Tevera, 2011:287). The contribution of UA to nutritional improvements has been well-recognised in literature. Mougeot (1999) claimed that it contributed effectively in various ways to the reduction of food insecurity, for example through ameliorating the food intake for households and for improving the nutritional status of children. However, Armar-Klimesu (1999:106) illustrated that although we can quite easily infer that improved access to a greater dietary diversity and food will ameliorate nutritional conditions in vulnerable groups, at that time, there were actually few studies conducted in African cities which 'rigorously' tested the link between nutrition and UA in children.

c. Urban Agriculture and Sustainable Development

With an increasingly urban world, and with the food needs of increasing urban populations, UA should be a key element of any plans which governments and planners develop to cope with these growing needs. Quite simply, as Deelstra and Girardet (1999:43) put it '(t)here can be no sustainable world without sustainable cities'. These authors went on to explain that cities indeed

have an 'enormous potential' to produce food, despite their population densities (Deelstra & Girardet, 1999:46).

Another weakness of UA research is its isolation from the sustainability agenda and aspects of the urban food system. No reference to sustainability or goals of sustainable development would be complete without reference to the Brundtland Report of the WCED of 1987. UA was, in fact, mentioned in that report, although it is not necessarily the most often quoted part of the report. The Brundtland report stated that UA which is 'officially sanctioned and promoted ... could become an important component of urban development and make more food available to the urban poor' (WCED, 1987:174). Although much research has been done on various aspects of UA, some authors and practitioners would argue that we are still waiting for that ship (i.e. greater food availability) to come in.

In the early 2000's, there were some concerned authors questioning the real sustainability of UA. These included Lynch, Binns and Olofin (2001), who pointed out that although there has been a lot literature on the positive aspects of UA thus far, there is also some literature which has started to raise concern of UA's impacts on people and the environment. The work of Lynch *et al.* (2001) was based on a case study in Kano, Nigeria, which, using empirical evidence, showed the livelihoods of people carrying out UA there were becoming threatened by things such as land development encroaching on UA areas, as well as land tenure insecurity (Lynch *et al.*, 2001).

Mougeot (1999) also commented on concerns around practising UA. He suggested most concerns about UA came from public health, environmental and urban planning departments. Concerns include those such as exposure to pathogens associated with livestock, as well as with human waste excreta (see Mougeot, 1999). Other environmental concerns relating to UA include negative impacts it can have on urban ecology, such as on water sources (e.g. siltation and depletion), as well as soil erosion, the destruction of vegetation and pollution of soil, water and air (see Mougeot, 1999).

d. Cities, Urban Agriculture and Urban Ecology

Cities are reliant upon the environment in which they are built and develop for the resources (human and natural) that they need to function. The natural resources are a part of the underlying natural ecology of the areas where cities are located. The concept of urban ecology grew around the 1970's when the impacts of human activities on the Earth were well-known and the size of human settlements was growing (McDonnell, 2011). This was causing major environmental problems and threats to the health of people in urban and non-urban areas of the world (McDonnell, 2011).

Factors involved in urban ecology are processes of recycling of nutrients and of waste management (Deelstra & Girardet, 1999). The metabolism (or flow of resources, energy and wastes) in traditional cities i.e. historical cities, was generally circular (Deelstra & Girardet, 1999). This meant that wastes generated in these kinds of cities were used as inputs in other processes, and in this way they were recycled. However, in 'modern' cities, this metabolism is linear (Deelstra & Girardet, 1999:50). This means that resources become 'funnelled through the urban system without much concern about their origin and about the destination of wastes ...' (Deelstra & Girardet, 1999). In this way, we can see that outputs and inputs have been treated as if they are unrelated (Deelstra & Girardet, 1999). These authors assert, as we are now well aware, that these kinds of linear systems that we see in the metabolisms of our contemporary cities are unsustainable.

Circular metabolisms can be found in natural systems, where ecosystems in nature are like large circles – because each output from one organism is also an input (Deelstra & Girardet, 1999). This circular movement of resources is able to sustain and renew the entire living environment (Deelstra & Girardet, 1999). There is a need for cities to design systems for their metabolisms that are circular, for ensuring the long-term viability of the environments upon which they are dependent (Deelstra & Girardet, 1999). Thus, the outputs from urban areas also need to be considered as vital inputs into production systems in urban areas (Deelstra & Girardet, 1999). In other words, 'sustainable development is unthinkable without sustainable urbanization' (Smit & Nasr, 1992:152).

Acknowledging broader sustainability goals and how they relate to UA also requires us to face the fact that UA has both positive and negative impacts on the environment (Crush, Hovorka & Tevera, 2011). The Brundtland Report suggested that the main reason for promoting UA should be for improving health and nutrition standards in the poor (WCED, 1987). Critically, and connected to these health standards, the report highlighted that UA can (and should) contribute to '... the clearing of garbage dumps and recycling of household waste' (WCED, 1987:174). In addition, Deelstra and Girardet (1999) alluded to the numerous benefits that farming in urban areas could provide, including creating a better microclimate, conserving soils, minimising waste, improving water management and the recycling of nutrients, as well as raising the environmental awareness of residents. Thus, positive impacts of UA on urban ecology include its potential to improve (human) health by being able to 'clean up' urban areas through re-using solid waste, wastewater and organic matter (Belevi & Baumgartner, 2003; Drechsel & Kunze, 2001; Njenga *et al.*, 2007; Schertenleib *et al.*, 2004; in Crush, Hovorka & Tevera, 2011). All this leads us to the question of why there has not been more vigorous attention given to exploring and harnessing the value of organic waste recycling in UA worldwide (both academically and in practice), especially since the publication of the Brundtland report decades ago.

In order for UA to be carried out in cities, there need to be suitable consumers and partners to support the development of knowledge on opportunities which UA presents for protecting the ecology of cities (Deelstra & Girardet, 1999). However, we need to be aware that the main issue here is the need to recognise opportunities that exist for UA to be 'translated into sustainable initiatives' (Deelstra & Girardet, 1999:58). One of the main steps which these authors suggest is critical for ensuring that conditions are suitable for carrying out UA is to design policies and plans for UA, which take into account the complex and 'interrelated nature of health, ecology, agriculture and food by forming groups that can work on issues on food which have a 'total system perspective' (Deelstra & Girardet, 1999:59).

e. A reality check

The euphoria surrounding UA in the 1980's and 1990's was not without its critics. Some sceptics noted that UA '... claims too much and offers too little in the policy context of urban family food security' (Ellis & Sumberg, 1998:221). This meant that by claiming too much, it was suggesting that urban production implies improving the food security of urban poor (Crush, Hovorka & Tevera, 2011). The idea that it offers too little meant that UA did not take into account the role that rural areas play in describing the capabilities of the urban poor for survival (Crush, Hovorka & Tevera, 2011). Tevera (1999; in Crush, Hovorka & Tevera, 2011) shares the view that rural influences are under-acknowledged, explaining that the very poor as well as any people newly arriving to cities generally have poor access to land. This limits their opportunities for carrying out UA. A further problem when trying to understand this promotional UA research is that obtaining hard facts and data that actually illustrate and support how food security and nutrition of urban households has improved is extremely difficult.

Furthermore, Mougeot (1999:1) commented that, even at the time of his paper, UA seemed to be 'growing out of its ability' to cope with the diverse challenges of development. Mougeot (1999:1) recognised that this struggle was because UA was being pushed by a 'complex web of factors' that remained 'little understood', and especially pointed out that some of these factors included food insecurity and urban poverty. Mougeot added that if we are determined to understand and promote UA's impact on the lives of communities, we need to better understand how urban food systems work (1999:2).

f. Relying on flimsy science

Globally, knowledge of the '... importance, nature and food security implications of urban agriculture is plagued by a lack of good quality, reliable data' (Zezza & Tasciotti, 2010:265) Some authors have argued that the increasing body of literature on UA does not contain enough or adequate empirical research (Thornton, 2008). In addition, where there is research, it often 'suffers from a lack of proper "scientific inquiry"' (Burger *et al.*, 2009:9;). In addition, municipal authorities

sometimes have a paralysing fear of UA, because they continue to worry about its environmental effects (Cohen & Garrett, 2010). This contributes to the overall weakness, riskiness and perceived unreliability of UA as a means of providing a meaningful livelihood to urban residents.

The role of UA as a food security and livelihood strategy in urbanised areas and cities that are modernised is still not clear (Armar-Klemesu & Maxwell, 2000; Frayne, 2005; in Thornton, 2008:244). Key academic criticisms of UA research include that many 'sweeping statements' are made about the environmental and food security of households that are based on disjointed research activities and its generalisations (Thornton, 2008:245). Some of these issues include that there is a 'discrepancy' between claimed ecological benefits of carrying out UA, and those which actually happen (Webb, 1998a:95). Further, Hovorka (2005) suggests that this kind of UA research does not explain what effects the location and relationships in the human-environment can have on different UA production systems. Literature is calling for more empirical research in UA to investigate whether it can actually achieve what it claims (Burger *et al.*, 2009). There has also been a major tendency and bias to focus on UA crop production rather than on livestock production (Thornton, 2008).

g. To grow or not to grow: The Failure of Urban Agriculture?

Urban agriculture is often punted as a one-size-fits-all interventionist solution to urban food insecurity issues around the world. It is widely claimed as being a suitable livelihood strategy for the poorest households in urban areas, as means of creating income and tackling food security (Thornton, 2008). However, as Crush and Frayne (2010) aptly put it, urban food security is not simply about food gardens in backyards, nor is it about food transfers from rural areas. Correspondingly, despite large amounts of research into UA over some decades, these investigations have all come to 'markedly different conclusions' (Crush, Hovorka & Tevera, 2011:285).

This variation in UA research results is reiterated by Ruysenaar (2013:1), who concluded that UA has 'potential but ambiguous and modest' benefits. There is a great need to explore the implementation of UA, as well as what actually happens when it is carried out (Ruysenaar, 2013). More research needs to be done in terms of the 'practice of urban agriculture', as well as its 'implementation in specific contexts' (Ruysenaar, 2013:1). We also need to consider how or why existing approaches to UA '... may continue to dictate the actions that seem to be failing' (Ruysenaar, 2013:26). One way to do this is by applying '... a far wider appreciation of the concerns around how urban agriculture is socially constructed ...' (Ruysenaar, 2013:26). This will need to involve a 'more cautious and considered' way of researching the real benefits and limitations of UA to the urban poor (Crush, Hovorka & Tevera, 2011:287).

h. Urban Agriculture in Southern Africa

As we have seen, there has recently been strong criticism of the impacts, extent and even the actual potential of UA to contribute meaningfully to the lives and nutrition of the urban poor. Also, it seems UA is not as widely practised as was once assumed (Crush, Hovorka & Tevera, 2011). However, there appears to be much regional and national variation around Southern Africa regarding how much people actually depend on UA as a source of food.

The AFSUN surveys conducted around Southern African cities in 2008 indicated that the percentage of households practicing UA ranged from 64% in Blantyre to just 3% in Windhoek and Lusaka (Crush, Hovorka & Tevera, 2011:14). To complicate matters further, in some countries of Southern Africa, UA is interpreted as a reaction to adverse economic conditions - such as in Zimbabwe (see Drakakis-Smith, Bowyer-Boyer & Tevera, 1995; and Mudimu, 1997). While the economic and political situations are different between countries, one needs to remember that the figures on UA frequency represent a complex and constantly changing mix of socio-economic and environmental factors that play out in these respective countries.

6. Urban Agriculture failure in South Africa

a. How green are South Africans' fingers?

Urban agriculture was seen to be a way of bettering the 'plight of the urban poor', and was a strategy which was promoted since the early 1990's in South Africa (Webb, 2011:195). As part of key post-apartheid policy documents in South Africa, UA was also promoted for working on poverty alleviation (Thornton, 2008). In general, South Africa presents a particularly complex conundrum amongst other Southern African countries with respect to UA and its contribution to the urban poor's livelihoods and food security. UA is, in fact, not generally a significant food source for the urban poor – even when these people live close to agricultural areas (Battersby, 2011a). Indeed, on a household level, very little production of food is taking place, meaning that any potential which South African cities have to feed themselves is 'largely untapped' (McLachlan & Thorne, 2009:11). The Cape Town AFSUN surveys of 2008 found that just 2% to 9% of poor households in the city practised UA (Battersby, 2011a:22). However, to illustrate the depth and complexity of characteristics of UA in South Africa, it can be said that the variation of the occurrence of UA in the cities of Cape Town, Msunduzi and Johannesburg indicates that of those families which were practising UA, 31% were actually totally dependent on what they produced (Frayne *et al.*, 2009:26). This suggests that these families could actually be relying on UA as a survivalist strategy for ensuring their access to food. Furthermore, if these families rely on UA as their only source of fresh produce, this could imply that they actually have very little or no income in general, or little available income to spend on food.

Following on from this, some academics are concerned that even though South Africa has high unemployment rates, UA could be ‘... less robust in South Africa’s urban poor households than other developing countries’ (Thornton, 2008:243). However, it is important that we realise that just because UA is not necessarily commonly practised around the country, this does not mean that it does not have the potential to contribute more to the food security situation of the urban poor (Crush, Hovorka & Tevera, 2011).

b. Money talks

So why is UA failing in South African cities? One answer to this could be that cash still seems to be the main resource contributing to food security in South African households (Crush & Frayne, 2010). This fact is reinforced by Joubert (2012:91), who says that southern Africans are ‘... dependent on cash at some or other level in order to keep their plates even modestly full ...’. This means that most poor urban residents prefer to scrape together whatever money they need to meet their daily needs, rather than to start a home food garden or receive food as a form of payment for any work they do manage to get. In addition, apart from the right to food, the Constitution of South Africa states that where people are unable to support themselves, they have the right to social security assistance (Government of South Africa, 1996). This assistance comes in the form of social grants which recipients are expected to use to support their needs, including their access to food.

A further complication to the link between food prices and the economy is the fact that the urban poor are generally more susceptible to food price rises (Crush & Frayne, 2010). This is mostly because they spend a larger proportion of their budgets on food than residents living on higher incomes.

These points lead us to the question of how dependent the urban poor actually are on UA as a livelihood strategy. Research findings in the small towns of Peddie and Rhini in the Eastern Cape of South Africa found that social grants were more important than UA in providing for better food security for most of the urban poor there (Thornton, 2008). Thornton (2008) also found that families not receiving social grants in Rhini and Peddie were the most destitute, but were not the most reliant upon UA. However, these families did rely somewhat on home gardens. This finding contests claims that there are measures relating to crop production (such as amount and value of crops consumed) which are ‘intimately connected to household welfare’ (Webb, 1998b). Thornton (2008) recommended that families not receiving social grants need to be identified. These families, despite practicing UA are ‘... at the extreme end of poverty ...’ and worryingly ‘... are the most vulnerable to illness and malnutrition’ (Thornton, 2008:259). In addition, there is a need to educate people who *do* receive grants that these grants should be used as a ‘stepping stone’ to livelihoods which are more sustainable (Thornton, 2008:259).

c. Not on the agenda

Another factor that compounds the often disappointing results of UA in South Africa is that agriculture is almost never recognised as a legitimate land use in urban planning (Crush, Hovorka & Tevera, 2011). Municipal authorities are often not able to understand how UA can be included in planning (Cohen & Garrett, 2010). This is reflected in the paucity of policies and frameworks for promoting, managing and planning UA around Southern Africa. In fact, Cape Town is the only city in South Africa to have drawn up its own set of UA policies. However, these policies are focussed mainly on driving food security advocacy (Battersby & Marshak, n.d.).

In addition, UA may be a 'last resort' for poor urban households, 'rather than a choice' (McLachlan & Thorne, 2009:11). This begs the question about how this 'last resort' can be remodelled so that it is attractive to the urban poor, especially to informal settlement residents. Frayne *et al.* (2009:25) suggest that we need to be '... mainstreaming urban agriculture into the fabric of how the city feeds itself ...' – but how are we to go about doing this? What does their suggestion mean in real terms, in the context of desperate and everyday lives and needs of the urban poor? How can this so-called 'mainstreaming' actually be achieved? How can it practically and physically be done on the ground? What are the social conditions necessary for UA to have a fighting chance for success in South African cities?

d. A question of space

The use of urban space for cultivation means it competes directly with other issues such as demands for shelter for the poor (Burger *et al.*, 2009). These demands tend to be felt as being more urgent, and as a result, food production and food waste management concerns fade into the background. Another perspective on the limited UA activity in South Africa is the fact that areas with dense urban populations simply have little space to offer for poor populations to cultivate food (Potts, 1997; in Thornton, 2008). Such simple, obvious and coherent explanations of UA failure in UA discussions are hard to find, and yet they are often the most logical explanations for the failure of UA.

How can the urban poor be expected to carry out UA when in real and practical terms they are living in increasingly cramped and inhumane conditions, where issues such as housing and sanitation are their more urgent needs? Furthermore, it is difficult for UA to be considered in such areas, perhaps due to the lack of readily accessible water, or even access to greywater resources. The answers to this and other questions on UA failure in South Africa can most effectively be tested by exploring what kinds of social and practical innovations could work in an authentic, low-technology and resource-poor informal settlement context.

These kinds of innovations include the use of recycled food waste as a source of nutrients for soil conditioning, and therefore one way of tackling UA challenges and improving its productivity in South Africa and elsewhere (while at the same time working on waste management issues). Innovations could also include the intensification of vegetable production in smaller areas, especially due to the competition for space and cramped conditions in informal settlements. This intensification would, however, probably need more labour, nutrients and water inputs. In addition, innovations would need to consider the role of education, cultural adaptation, research, mainstreaming of waste recycling, as well as that of understanding needs and demands of residents of informal settlements. Through doing this kind of grassroots work, we can meaningfully engage with how UA can ‘... provide a very powerful stimulus to civil society ...’ (Frayne *et al.*, 2009:25).

e. The future of South African Urban Agriculture

A key point of concern for the continuation and sustainability of UA inter-generationally is how it is seen by the youth. Thornton’s (2008) research indicated that the strongest negative feelings towards UA were observed amongst the youth. These youngsters saw UA as being something that was ‘not modern’ (Thornton, 2008:257). Again, this provides an interesting window for research. This is the exploration of the willingness and interest of youth to participate in communal activities aimed at increasing the productivity of UA *in situ* (through localised soil restoration and composting). This kind of investigation could also seek to find out what aspects would make UA attractive to them.

f. Size matters – or does it?

The blinkered-vision among UA researchers and policy-makers is compounded by their tendency towards a ‘large-city bias’ (Burger *et al.*, 2009:9). This means that research has gravitated to studies in large urban city centres, with smaller ones being left by the wayside. This also means that the attention of policy-makers is only focussed on these large centres (Thornton, 2008). These tendencies are extremely worrying, given that the poverty burden is highest in non-urban centres in South Africa (Thornton, 2008).

g. An elephant in the room

Decades of UA research by academics and organisations around the world have resulted in significant resources being spent debating the merits and demerits of UA. Whilst these debates may continue, the fact remains that those advocates for and against UA are avoiding the real elephant in the room – the plight of the very soil in (and on) which all our food grows. Literature on the recycling of urban organic waste sources for composting (and soil building) and their relationship with UA enterprises (at least in South Africa) is virtually nonexistent. There have, however, been some commendable studies conducted on aspects relating to composting, waste

recycling and on UA in general (see Smit & Nasr, 1992). However, UA studies do not often seem to be holistic, and tend to follow single disciplines and topics, or a kind of blinkered 'silo thinking' typical of academic, organisational and policy research around the world (see, for example, Drakakis-Smit *et al.*, 1995; Ellis & Sumberg, 1998; Slater, 2001). Thus, there appears to be a paucity of studies on organic resource cycling, soil restoration and food waste management that links them explicitly to UA. It is argued in this thesis that these opportunities and links urgently require further research.

h. Declaring a truce?

Webb (2011) questions whether we have reached a point where advocates of UA will admit that there is enough counter-evidence to claims of the success of UA. However, Webb (2011) goes on to debate whether it is still a good idea for UA critics to continue with their argument. He ends by compromising hopefully, saying that by contemplating both of these perspectives, we should be able to consider UA research more deeply (Webb, 2011). Also, referring specifically to the food system, Drimie and McLachlan (2013) warn that focussing on the symptoms of problems commonly results in solutions that do not last long, and which can have negative unintended consequences. Cohen and Garrett (2010:479) optimistically suggest that UA is still '... an under-appreciated avenue to urban food security'. However, these authors also call for more 'comprehensive studies ... on the value of urban agriculture, to help scale-up successes' (Cohen & Garrett, 2010:480).

7. Social Learning for Improved Urban Agriculture and more Sustainable Food Systems

a. Definitions of Social Learning

There is currently no single agreed upon definition of Social Learning (SL). The definition favoured in this thesis is that suggested by Reed, Evely, Cundill, Fazey, Glass, Laing, Newig *et al.* (2010) who propose three components that SL needs to have. These include:

- a process of learning that occurs through social interactions and processes between actors within a social network;
- a change in understanding which takes place in the individuals involved as they discuss their ideas and debate the issues; and
- a change in understanding which extends beyond the individual and becomes situated within wider social units or communities of practice (Reed *et al.*, 2010).

Other authors, such as Dale (1989; in Cundill & Rodela, 2012) see SL as being an emergent outcome which results from interactions over the long-term. Dale (1989; in Cundill & Rodela, 2012)

describes SL as being a shared process among various diverse groups, which is used to understand rapidly changing and complex environments.

These ideas on SL are advanced by Pinkerton (1994; in Cundill & Rodela, 2012), who explains that SL occurs when different parties deliberate on problems, and where they carry out activities together, as well as show their perceptions and values, and monitor processes together. In a similar way, Daniels and Walker (1996) see SL to be a process of outlining issues and looking for alternatives to them, as well as discussing these choices in an inclusive process through public deliberation.

A significant beneficial addition to SL theories and understanding comes from Buck, Wollenberg and Edmunds (2001; in Cundill & Rodela, 2012), who suggest that SL is able to improve capacity for acting together, for building relationships, and for reducing or solving problems. Furthermore, Ducrot (2009) claims that SL is a kind of learning that occurs in a group of people who all want to improve a situation that they share, and who also want to take collective action.

Other authors suggest that SL can be thought of as a ‘... process of change on a society level ... based on newly acquired knowledge, a change in predominant value structures, or of social norms which results in practical outcomes’ (Luks & Siebenhüner, 2007:420). In the process of SL, a wide range of social groups and actors are involved, such as activist groups, scientific communities and political decision-makers (Luks & Siebenhüner, 2007). For SL to occur, a sufficient level of interaction between groups and actors is needed so that problem-orientated knowledge can be generated and used practically (Luks & Siebenhüner, 2007).

b. Community engagement and Co-generation of Knowledge

The challenges of the food system, especially regarding how low-income populations relate to them, need a transdisciplinary approach. This approach needs to facilitate solutions to seemingly unconquerable problems through co-creation and co-learning of these solutions (Drimie & McLachlan, 2013). Urgent action is needed in this regard, as recent literature explains that strategies that currently exist to combat the complex challenges which food systems face have failed (Drimie & McLachlan, 2013).

c. Using Social Learning for Understanding Complex Socio-Ecological Problems

Practitioners and researchers who attempt to work with SL via the natural resource management literature are commonly confused by the wide range of outcomes and processes that they find in this literature (Cundill & Rodela, 2012). These contrasts mean that it is often difficult for researchers to know where to focus their efforts and attention (Cundill & Rodela, 2012).

8. Nutrition

a. Under-, Over- and Malnutrition in Southern Africa

Undernutrition was once called a 'silent emergency' (UNICEF, 1998:9). In 2010, the FAO reported that about 30% of the Sub-Saharan population was undernourished – the highest percentage in the world at the time (FAO, 2010:11). Rapid urbanisation and changing diets are causing a second silent emergency in developing countries – that of obesity (Crush, Frayne & McLachlan, 2011). Changing to highly processed diets often occurs when residents migrate from rural to urban areas (Crush, Frayne & McLachlan, 2011). Urban residents have cheap and easy access to these 'empty' calories (Joubert, 2012:143). These foods are high in calories but low in nutritional value. Therefore, having a small but regular supply of fresh produce can play a great role in improving nutrient intake, even if these nutrients do not necessarily contribute to bulk calorie dietary needs.

Coupled with the challenge of food insecurity in poor urban populations is the increasing incidence of diabetes and obesity (overnutrition) amongst these populations. Both under- and over- nutrition are placing an increasing burden on the urban poor in Southern Africa (Crush, Frayne & McLachlan, 2011). In the South African National Health and Nutrition Examination Survey (SANHANES) of 2013 it was found that, in clinical examinations, almost one in five of the participants (18,7%) had impaired glucose homeostasis, with diabetes being diagnosed in 9,6% of these participants (Shisana, Labadarios, Rehle, Simbayi, Zuma, Dhansay, Reddy *et al.*, 2013:6). Furthermore, the SAHANES of 2013 found the incidence of diabetes and impaired glucose homeostasis was higher than 10% in five of the nine provinces examined (Shisana *et al.*, 2013:6). This health-diet paradox is resulting in increasingly complex and interlinked issues relating to food, poverty, health and livelihood systems. This makes addressing urban food security even more challenging and problematic.

b. Nutrition, vulnerability and economic productivity

Undernourished people do not have enough physical or mental strength to work. This means they cannot access gainful employment or meet the daily needs of their families. From this angle, we can see that the presence of undernourished people in a city also impacts the social and economic development of that city (Battersby, 2011a). This is because they are too weak or become sick and so cannot work regularly, or carry out their jobs adequately and competently. This ultimately reflects on the overall productivity of their employers' companies, as well as in these employees' access to opportunities for improving their skills and education.

The connections between diseases such as AIDS, with poverty, nutrition and food are now well understood (McLachlan & Thorne, 2009). The effects of debilitating nutrition-related diseases such as HIV and tuberculosis are especially pervasive in South Africa. In 2011, in the Stellenbosch

Municipality, the reported number of people who were HIV positive was 7365, and the number of AIDS deaths in that year was 339 (Stellenbosch Municipality, 2013:23). Current and continuing research being done by the International Food Policy Research Institute (IFPRI) highlights just how complex the socio-economic and biological aspects of HIV and AIDS are (see Gillespie & Kadiyala, 2005; and Gillespie, 2006). IFPRI's research furthermore shows that food poverty is directly involved in both affecting physiological vulnerability to HIV, as well as in the risky behaviour associated with the virus (Gillespie & Kadiyala, 2005; Gillespie, 2006).

9. Food 'Waste' – opening Pandora's Box

a. The great exposé

The 'increasing alarm' about regional food shortages and food prices has 'pulled the focus in on the matter of food waste and how much it contributes to the(se) problem(s)' (Joubert, 2012:92). Indeed it is ironic that both food waste and global hunger are increasingly becoming 'significant global issues' (Nahman, de Lange, Oelofse & Godfrey, 2012:2147). Worldwide, roughly one third of food edible for humans is wasted or lost – this amounts to about 1,3 billion tonnes per year (Gustavsson *et al.*, 2011:4). Some studies have gone so far as to estimate that total food losses for human consumption from 'field to fork' may even be as high as about 50% of total food production (Lundqvist, de Fraiture & Molden, 2008:4).

Another shocking statistic is that food waste generated by consumers in industrialised countries is almost as high as the net total food production in Sub-Saharan Africa (222 million tonnes compared to 230 million tonnes) (Gustavsson *et al.*, 2011:5). Food loss figures in Sub-Saharan Africa amount to about 170kg per person per year (Gustavsson *et al.*, 2011:5). The similarity of these waste and production levels has been accurately described by Joubert (2012:93) as a 'grotesque unfairness'. The frustration of these injustices is also felt by Stuart (2009; in Joubert, 2012:94), who says '(t)he connection between food profligacy in rich countries and food poverty elsewhere in the world is neither simple nor direct ...'.

In low-income countries there is not much wastage of food at the consumer end of the supply chain – food losses in these regions generally occur in the middle and early parts of the supply chain (Gustavsson *et al.*, 2011). To this end, Marshak (2012) points out that there is very little literature associated with food waste in the global South or developing country context, and furthermore that most research on this kind of waste has been done in Europe, Asia and America. Some data on food waste for southern Africa does exist – for example, 6kg per person per year of food is wasted after sale at retailers in Sub-Saharan Africa (Joubert, 2012:93). Limited incomes and poverty levels mean that wasting food in developing countries is 'unacceptable' (Gustavsson *et al.*, 2011:13). In fact, contemplating food waste in a low-income area and especially in an informal settlement context in Southern Africa is almost inconceivable.

Thus, it is possible that poor urban residents produce the lowest amounts of food waste of all consumers. It is also likely that they have lowest impact on resource consumption and therefore ecological degradation. However, the widespread lack of infrastructure and capabilities of informal settlement residents to store food could mean that their food spoiling and wastage levels are higher than one may initially expect.

b. Global ecological footprint of food waste

There are numerous reasons why food waste is problematic – one being that it is a loss of potentially valuable resources for other uses (Nahman *et al.*, 2012). Estimations by the FAO (2013a:6) indicate that the carbon footprint of food that is wasted globally is to the tune of about 3,3 Gtonnes of carbon dioxide. This enormous footprint means that if global food waste were considered to be a country, the emissions from this global food waste would rank third amongst the top world emitters, after the United States of America and China (FAO, 2013a:6). The amount of land that is filled with agriculture for growing food that is not eaten globally is about 30% of the world's total agricultural land area (FAO, 2013a:6). Furthermore, the bluewater footprint (i.e. the use of surface water and groundwater stores) associated with this global food waste amounts to about 250km³ of water, or approximately the annual discharge of the Volga River (FAO, 2013a:6). In addition, Lundqvist *et al.* (2008), remind us that one of the principle constraints to food security will be water, unless we are able to change the ways we interact with and contemplate the entire food chain.

c. Recognising the value of food 'waste'

Global economic costs of food losses (excluding seafood and fish) have been calculated to be about US\$750 billion, based on producer costs only – this is roughly equivalent to the Gross Domestic Product (GDP) of Switzerland (FAO, 2013a:7). Together with the land, water and carbon dioxide impacts of food waste, we can see that '... a reduction of food wastage at global, regional, and national scales will have a substantial positive effect on natural and societal resources' (FAO, 2013a:7).

Reducing food waste could play a significant part in tackling major development challenges, such as food security, protecting environmental resilience as well as improving of the livelihoods of farmers (Lundqvist *et al.*, 2008:5). However, the true potential of such waste reductions to feed the world's hungry needs to be systematically analysed, given that the world food system is enmeshed within embedded and complex pathways and feedback loops (such as recycling and re-use at various parts of the supply chain, which vary from country to country).

One such example of the complexity in food systems is that one of the main reasons for losses in the food chain is the growing distances between the locations where food is consumed and produced (Lundqvist *et al.*, 2008). By investigating how supply chains can be shortened, as well as carrying out full-impact analyses of food production systems (such as Life Cycle Analyses), we will arrive at a better understanding of the real costs of food waste. In addition, we must be mindful that even if we improve the efficiency of one part of the food chain will be worthless if wastage or losses happen or increase elsewhere in the chain (Lundqvist *et al.*, 2008). Furthermore, Lundqvist *et al.* (2008) point out that we should not forget that agricultural products which are harvested but which we do not see on our plates may not necessarily be wasted. This is because residues and produce are used in different ways at the farm level or in the greater agricultural system (Lundqvist *et al.*, 2008). These uses include purposes such as production of bioenergy, soil improvement or feed for farm animals (Lundqvist *et al.*, 2008).

Encouragingly, awareness of global food waste amongst research institutions and organisations is increasing. Food losses can have the following impacts: on economic development, on the environment, on food safety and quality, and on food security of the poor, among others (Gustavsson *et al.*, 2011). Losses in food mean that we also waste the resources used to produce it - such as water, land and energy (Gustavsson *et al.*, 2011). By not using food that is produced for consumption, unnecessary carbon dioxide emissions are produced, and the actual economic value of the food is decreased (Gustavsson *et al.*, 2011). Improving efficiencies in food supply chains (by reducing losses along the chain) could bring food prices down and make food more affordable to consumers (Gustavsson *et al.*, 2011). However, we need to consider the implications of reduced food prices very carefully. If food becomes more affordable, then those who were already able to afford it before prices dropped it may simply buy more food. In so doing, these people would probably generate higher quantities of food waste. Perhaps, rather, we should consider that the true cost of processed food should be paid by the consumer. It is possible that through this, the amount of food that rich consumers are able to spend on food could be more limited, and therefore potentially reduce the amount of food waste these kinds of consumers generate.

d. Food 'waste' in South Africa

Disposing of food waste to landfill is also a significant contributor to leachate and greenhouse gas emissions (Hartmann & Ahring, 2006; Waste Resources and Action Programme, 2008; in Nahman *et al.*, 2012). In South Africa, waste contributes 4,3% of national greenhouse gas emissions (Department of Environmental Affairs, 2009; in Nahman *et al.*, 2012:2148). The South African government has highlighted the need to reduce amounts of organic waste going to landfill (Department of Environmental Affairs, 2010; in Nahman *et al.*, 2012). In fact, in some countries, sending organics to landfills is illegal. Also, apart from the social cost of food waste, throwing away

inedible food ‘... represents the loss of a potentially valuable resource that could be used as an input to other processes, such as composting ...’ (Nahman *et al.*, 2012:2148).

The South African National Waste Management Strategy of 2011 mentioned the need to phase out practices including the disposal of solid and liquid wastes together, as well as of the disposal of organic waste (which includes food waste) to landfill (Department of Environmental Affairs, 2011). This phasing-out is described as being a priority for improving the management of hazardous waste (Department of Environmental Affairs, 2011). A study done in the Western Cape showed that in Cape Town, the portion of organics in landfills ranged from about 3 to 4%, while in rural areas it ranged from about 8 to 24% (Silbernagl, 2011; in Nahman *et al.*, 2012:2150). However, the country still has a long way to go in the process of formalising legislation against sending organic waste to landfill. When emphasising sustainable waste management, the South African government and residents need to focus on preventing and minimising waste, as well as recycling, re-using and treating it. Disposal of waste to landfill should only be a ‘last resort’ (Nahman *et al.*, 2012:2148).

It has been suggested that condemned food and post-consumer waste forms a ‘noticeable waste stream’ in South Africa (Nahman *et al.*, 2012:2148). Domestic waste generated by low income groups in South Africa has been estimated to be 0,41kg per capita per day, in middle income groups it is 0,74kg per capita per day, and in high income groups it is 1,29kg per capita per day (Nahman *et al.*, 2012:2149). In terms of representation of the population, the low income group makes up about 74% of South Africa’s population, while the high income group comprises just 4,6% of the population (Nahman *et al.*, 2012:2150). Based on these figures, it can be argued that attention should be paid to low-income areas in terms of their potential for proportionately reducing amounts of waste going to landfills around South Africa.

McLachlan and Thorne (2009:12) call for South Africa’s cities to be ‘... part of a new approach to food production that includes the agricultural, processing, marketing, transportation, consumption and waste aspects of the food system’. This researcher explores a number of methods of food waste composting or recycling that offer alternative, practical, informal, compact (space-savvy) and local *in situ* ways of using food waste in the Enkanini community, which could contribute directly or indirectly to food production or to sale or use of value-added products in the area.

Perhaps not surprisingly, there appear to have been very few studies done in Africa on food waste. In fact, the reuse of waste in agriculture has been described as being ‘everywhere underresearched’ (Furedy, Maclaren & Whitney, 1999:136). And yet it is well-known that the production of food which is based on sustainable development principles can be enhanced if both organic residues and nutrients resulting from urban consumption are able to be reused safely

(Furedy *et al.*, 1999). The effects of a lack of information and interest in food waste in South Africa are pervasive. In addition, there is no national data set on food waste for the country, though some ad-hoc municipal studies have been done (Nahman *et al.*, 2012). Unfortunately, comparing these studies is difficult as their classification of waste types varies (Nahman *et al.*, 2012). It is now clear that food waste in cities is a valuable resource for making compost, feeding livestock and producing energy (Marshak, 2012). However, in Cape Town, and generally around South Africa, food waste remains 'an underutilised resource' (Marshak, 2012:11).

A study in the city of Rustenberg (Silbernagl, 2011; in Nahman *et al.*, 2012:2150) found the weight of food waste as a percentage of the total weight of domestic waste collected at different households was as follows: 27% in low income, 13% in middle income, and 17% in high income areas. These statistics are interesting, because although low income groups are likely to consume less in general, food waste in this category makes up a greater portion of the waste generated by them than that of better-off residents. This finding is mirrored in a waste characterisation study done by the Stellenbosch Municipality in 2012. It indicates that Enkanini's organic waste proportions are even higher than those of Rustenberg's poorer areas. The characterisation study found Enkanini's organic waste made up more than 50% of the total domestic waste by weight for the area (von der Heyde, 2012:2).

e. Diverting food waste from landfill

One of the most significant effects of sending food waste to landfill is that this becomes a major source of methane emissions (Moomaw, Griffin, Kurczak & Lomax, 2012). Second, sending food waste and organics to landfill represents a blatant waste of landfill space. Most organic waste can be separated and composted easily, and does not usually pose a major toxic hazard threat when decomposed or degraded. This means that often it does not need to be put in a specially protected and lined landfill. However, organic waste can produce leachate, which has the potential to contaminate groundwater supplies (Nahman *et al.*, 2012).

Sending waste to landfill is now becoming a less attractive option for the disposal of waste for a variety of reasons. These include i) the lack of sufficient areas of land close to areas where waste is actually generated; ii) uncontrolled emissions of landfill gas (methane); and iii) production of leachate (Hartmann & Ahring, 2006; in Greben & Oelofse, 2009). Disposing organic waste to landfill also has numerous negative externalities (social and environmental costs) because its disposal is unnecessary. These costs include i) landfill gas generation (which is harmful to humans and the atmosphere); ii) vermin attraction; iii) waste transporting; and iv) generation of noise, smells and other irritations associated with living close to landfills (Nahman *et al.*, 2012).

A key benefit of composting green (organic) waste is that it saves landfill space (Resource Management Services, 2012). Other benefits of composting of green waste include i) production of compost that is of good quality and which has a market value; and ii) reduction of greenhouse gas generation (Resource Management Services, 2012). However, the sale of compost is dependent on the green waste having a consistent quality and not being contaminated (Resource Management Services, 2012). In addition, it is necessary to highlight that linking food waste to the generation of other inputs or products (such as compost) implies or assumes that people using these products will have access to water, land and other resources (such as time) to produce food.

The promulgation of the National Standard for the Disposal of Waste to Landfill will require increased green waste diversion from landfill over the next three to five years (Resource Management Services, 2012:2). In the context of the Stellenbosch Landfill crisis at the Devon Valley site, consultants recommended that Stellenbosch Municipality follow the City of Cape Town's lead and take up the 'No Greens to Landfill' policy (Resource Management Services, 2012). Taking up such a policy would therefore be in line with the National Standard (Resource Management Services, 2012).

f. Calculating the cost of food waste in South Africa

In order to calculate the value of edible food wasted for each income bracket over South Africa, Nahman *et al.* (2012) used proportions wasted and multiplied this by food basket values for each income bracket. Results showed that in the low income bracket, this value was about R12,7 billion per annum (Nahman *et al.*, 2012:2150). However, these calculations were based on developed country figures of the proportions of edible food thrown away (a figure of 81%) because this figure was not known for South Africa (Waste Resources and Action Programme, 2008; in Nahman *et al.*, 2012). This kind of assumption is very general and is probably not that useful for further consideration here. However, calculations could be adjusted using the statistics of poorer areas such as low-income groups in Rustenburg and Enkanini to get more accurate estimations of these costs.

Calculations have been done to add the cost of wasted food (as calculated by Nahman *et al.*, 2012) to the cost of its disposal to landfill in South Africa, using values from 2009 and 2010 in Cape Town. This was then extrapolated for all centres in South Africa. The final figure shows that food waste and its disposal is estimated to cost South Africa about R22 billion per annum, or about 0,82% of annual GDP (Nahman *et al.*, 2012:2152). However, these figures are only based on post-consumer waste (i.e. food that is wasted during the preparation of food in households) and condemned food (i.e. food which is past its sell by or shelf date in retailers). These amounts of food waste apparently only make up a small portion of the South Africa's total food waste (i.e. food that

is wasted along the whole supply chain, from farms to retailers). Thus, one can reasonably assume that costs associated with total food waste are actually much higher (Nahman *et al.*, 2012).

g. Closing the food waste and resource loop

More recently, discussions and discourse have emerged relating to how we can think about managing resources in cyclical ways, as well as the recycling of wastes in industrial systems (Marshak, 2012). These ways of thinking have been used to form new models, fields and concepts (Marshak, 2012). Some examples of these models and applications include i) cleaner production; ii) closed-loop supply chains; iii) zero waste to landfill; and iv) industrial ecology (Marshak, 2012). Despite the fact that these models and applications are relevant at various scales, their common characteristic is their reference to the necessity for avoiding linearity and instead moving towards more cyclic or integrated systems, similar to those which are found in nature (see Seuring, 2004; Marshak, 2012).

Although it has multiple challenges, mimicking nature's cyclical treatment of waste needs to be an integral and major objective of food systems and urban development in general. It is helpful to think about how to do this through the concept that 'nature knows no waste' - as such, we need to create production systems that are modelled on natural systems (Marshak, 2012:26).

Many authors are now beginning to make the (circular) connection between waste and UA. For example, Deelstra and Girardet (1999:51) point out that '(t)he relation between urban agriculture and waste management is most pronounced in the use of organic wastes'. Furthermore, incorporating UA into food systems can also change how people living in urban areas see food (Deelstra & Girardet, 1999). This is because, often, the practical experience of producing food is generally missing in urban life (especially in developed countries), because 'people harvest at the supermarket' (Deelstra & Girardet, 1999:54). Although we cannot expect everyone living in urban areas to grow their own food, at the very least, UA has the potential to bring consumers and growers together (Deelstra & Girardet, 1999).

The key challenge in the South African food system is that there is a need to find ways of improving and maintaining food production, which at the same time protect ecosystem services (McLachlan & Thorne, 2009). We need to remember that this requires us not simply to find a technical solution, but rather to identify one that involves an approach which recognises the value of ecological services (McLachlan & Thorne, 2009). This approach will also need to involve co-operation and social interactions which are able to 'work with rather than against nature' (McLachlan & Thorne, 2009:20). Furthermore, and as a key learning from and for this case study, Oelofse and Godfrey point out that managing food waste cannot rely on technology alone:

'Technology solutions to waste management problems offer only part of the solution to sustainable waste management services. Successful implementation of technology is strongly dependent on enabling social, political, and economic environment that is supportive of the given technology' (Oelofse & Godfrey, 2009:1; in Marshak, 2012:7).

Food waste researchers have called for a 'consortium' to be brought together, including industry representatives, academia, civil society and policy makers, in order to work on designing practical and acceptable actions for halving losses and wastage of food by 2025 (Lundqvist *et al.*, 2008:7). This case study on Enkanini's food waste management can serve as a local example of such actions. This can be done by combining Enkanini's general lack of living space with its similar shortage of space for storing waste and with resource cycling concepts in general, so that ingenious and space saving ways of harnessing this 'waste' energy to close the food resource energy loop of the settlement can be designed. This will indeed require us to see these challenges with new eyes.

h. Prioritising Food Waste management methods

A useful way of planning how to manage food waste is to design a priority of use, such as through using a food waste hierarchy. In such a hierarchy, different uses of food waste can be made so that maximum use can still be derived of the waste at each level. One such example is presented here, in the form of an adaptation of the Waste Management Hierarchy described by the United States Environmental Protection Agency (US EPA) (see US EPA, 2012), which is as follows:

- Source reduction (reducing the volume of food waste generated at places where it originates);
- Feed hungry people (if food is still suitable and safe for consumption – to food banks and soup kitchens);
- Feed animals (if food is not suitable for human consumption, but still suitable and safe for animal feed);
- Industrial uses (e.g. waste oils can be used for converting to other fuels, food waste can be digested to produce gas);
- Composting (food waste can be used to create nutrient-rich soil fertilisers); and
- Landfilling – as a last resort, when all other options have been fully explored and exhausted wherever possible.

Although all these different options for managing food waste are appealing, their relevance, practicality and applicability in different contexts is likely to be different. Therefore a hierarchy can serve only as a basic guide for planning food waste management. Further to this, the US EPA hierarchy is more relevant to a highly industrialised and developed country context. However, it may be useful for designing a locally relevant hierarchy for Enkanini and as a means for analysing

waste-related work. The Enkanini hierarchy could also be modified so that it becomes more of a decision making tool, rather than a top-down perception of waste. The tool would mean that hierarchical levels are less important and that site relevance becomes more important in decisions for the kinds of waste management options followed in specific areas.

10. The crisis under our feet – soils and soil degradation

In 1990, when the last global assessment on soil conditions was conducted, it was estimated that 23% of global soils had been degraded (Swilling & Annecke, 2012:153). Furthermore, in 1990, 38% of agricultural land was degraded, and this figure has probably worsened since then (Swilling & Annecke, 2012:153). On a continental scale, Africa had about 321 million hectares of land that was arable, but almost half of this land has now become 'irrecoverable wasteland' (Swilling & Annecke, 2012:153). Critically, unless we are able to find ways to increase soil restoration investments in Africa, the projections for increasing yields in Africa will be unobtainable 'pipe dreams' (Swilling & Annecke, 2012:153).

Soils in South Africa are vulnerable, and land use practices in the country have already lead to negative effects that have caused soil degradation - such as changes in both their chemical and biological qualities (Mills & Fey, 2003:429). There is evidence that the country's soils have suffered 'considerable' nutrient depletion and acidification (Mills & Fey, 2003:434). In urban areas, reasons for soil degradation can include erosion (such as from increased runoff or compaction from humans or vehicles) and contamination (from urban activities such as construction and transport). The crisis of soils urgently needs to be addressed, both in rural and urban areas. This can be done in both areas by focussing activities on soil rehabilitation, as well as on promoting systems for agriculture that help to promote and develop soil and (biological) activity in the soil (McLachlan & Thorne, 2009).

McLachlan and Thorne (2009) provide another useful suggestion on the soil, not only regarding how to tackle the soil crisis, but also for fundamentally re-examining and re-shaping how we think about the global soil crisis and soils in general. They argue that if one considers South Africa from the national developmental state approach, then one should consider soils as being a kind of infrastructure (McLachlan & Thorne, 2009). This is because infrastructure attracts investment (McLachlan & Thorne, 2009). When we think of soils in this way, it should be easy to transition our way of thinking and our ideas to those related to how we can incrementally upgrade soil conditions in afflicted areas. The revitalisation of UA and composting activities offer us the chance to do this.

11. Bokashi Effective Micro-Organisms (EM)

Bokashi, originally created in Japan, is a natural and organic product for soil improvement (Jensen, Guilaran, Jaranilla & Garingalao, 2006). It is an organic fertiliser that has been fermented, and which contains a mix of nutrients and local (indigenous) micro-organisms (Jensen *et al.*, 2006).

According to Barnes and Burt (2009), the mix of microbes which Bokashi contains includes:

- yeasts (such as *Candida spp.* and *Saccharomyces spp.*);
- lactic acid bacteria (such as *Streptococcus spp.* and *Lactobacillus spp.*);
- photosynthetic bacteria (such as *Rhodobacter spp.* and *Rhodospseudomonas spp.*); and
- actinomycetes.

Yeasts can be classified as a kind of fungi which are able to grow both in the presence or absence of oxygen (aerobic or anaerobic conditions) (Barnes & Burt, 2009). When in anaerobic situations, yeasts ferment sugar into ethanol (Madigan *et al.*, 2000, in Barnes & Burt, 2009).

Lactic acid bacteria produce lactic acid as the main product of fermentation, and can also grow in the presence or absence of oxygen (Barnes & Burt, 2009). These microbes are able to grow successfully in acidic conditions with low pH values of about four (Madigan *et al.*, 2000; in Barnes & Burt, 2009:2). When producing lactic acid in the early stages of fermentation, this acid suppresses the growth of putrefying bacteria, as well as improves the availability of inorganic compounds (Sung Cheol, K., Young-Chae, S. & In-Soo, K., n.d.).

Actinomycetes are bacteria that have filaments and look like fungi. These microbes are only able to function in aerobic conditions, and they look like white 'mould-like' structures (Barnes & Burt, 2009). They are commonly known to have antibiotic characteristics (Madigan *et al.*, 2000; in Barnes & Burt, 2009). *Actinomycetes* in EM are able to fight against some kinds of gram-negative bacteria, which include pathogens such as *E. coli* (Barnes & Burt, 2009). In general, Bokashi EM are supposed to reduce the presence of pathogens in food waste by competing with them (Beraud, 2012). For example, lactic acid bacteria present in Bokashi EM have been shown to inhibit the growth of harmful bacteria such as *E. coli* and *Salmonella* (Ligocka & Paluszak, 2005). *E. coli* and *Salmonella* are classified as gram negative bacteria (Winfield & Groisman, 2003). *E. coli* are commonly known to be commensal in the lower gut of mammals, although harmful strains do exist (Pommepuy, Butin, Derrien, Gourmelon, Colwell & Cormier, 1996; in Winfield & Groisman, 2003).

The photosynthetic bacteria are classified as being purple, non-sulphur bacteria (Barnes & Burt, 2009). They occur naturally and most can grow aerobically through respiration (Barnes & Burt, 2009). Some of these bacteria grow anaerobically and in the dark, where they operate using

fermentative respiratory methods (Barnes & Burt, 2009). They can also use light as an energy source (Barnes & Burt, 2009).

Studies by Higa and Parr (1994) have indicated that inoculating cultures of EM into plant and soil ecosystems can have a number of benefits, such as:

- Improving soil health;
- Increasing growth, quality and yield of crops; and
- Improving soil quality.

The Bokashi composting process works such that organic matter is decomposed via a fermentation process (Barnes & Burt, 2009). When the dry Bokashi mix (usually the dormant organisms on rice or wheat bran) is used to treat food waste, a fermentation process is started. This means that food waste can be stored for longer, instead of it breaking down and rotting (von der Heyde, 2012). The micro-organisms use this food waste as a growth substrate, and for generating by-products which other microbes can use (Barnes & Burt, 2009).

Fermentation is a process which occurs in anaerobic conditions, where facultative organisms (like yeasts) convert carbohydrates and other complex organic molecules into simple organic compounds (Higa & Parr, 1994). These simple compounds are often easily absorbed by plants, and the process releases a fairly small amount of energy (Higa & Parr, 1994). In contrast, aerobic decomposition (also done by facultative organisms) of a substrate of complex organic molecules causes the complete oxidation of the substrate (Higa & Parr, 1994). This results in the release of gas, carbon dioxide, heat and much larger amounts of energy (Higa & Parr, 1994).

The use of EM to increase and improve the diversity of microbes in soils and in plants has often been highly successful (see Yamada and Xu, 2000; in Barnes & Burt, 2009). Bokashi EM (microbes mixed with rice bran and rice husks) has been used in agriculture around the world for the composting of raw organic waste, and it has been proven that the EM increase yields without the need for extra fertilisers (Green, 2009).

Some tests on composting using EM show that waste volumes can be decreased by about 33% (Bikasb, 2001:1). Other experiments done by Kahl and Daly (n.d.) using EM on kitchen waste show that anaerobic fermentation of the waste in sealed drums achieved significantly better results (compared to leaving waste with EM in open drums). These results included a reduction of fly attraction and increased crop yields (of lettuces). In their experiments, Kahl and Daly (n.d.) found that the soil conditions resulting from the burying of food waste with EM from open drums had higher percentages of nitrogen than those where sealed food waste drums were composted. Those authors suggested this was because the open drum food waste was experiencing a delayed

mineralisation process in the soil, and therefore had delayed nitrogen release for uptake by the lettuces (Kahl & Daly, n.d.).

Other studies have shown that application of Bokashi EM to soil directly promotes yields, plant growth and photosynthetic activity in sweet corn (Yamada, Kato, Fujita, Xu, Katase & Umemura, n.d.). The authors of this study concluded that this was possible because EM was able to increase root activity and root development (Yamada *et al.*, n.d.).

Green (2009) suggests that anaerobic fermentation of raw organic food waste with Bokashi can be very efficient – taking as little as about seven days to produce a usable end product which can be put into soil. Once in the soil, this mixture can be quickly converted into rich organic soil, which is useful for ‘sustaining microbial diversity’ in the soil (Green, 2009:5). Green (2009) tested whether anaerobically fermenting and composting of organic waste treated with Bokashi EM released any gases. The experiment results indicated that no measurable gases were released in either of the processes (Green, 2009).

The liquid waste that drains from food waste treated with Bokashi EM is also valuable as a fertiliser for soils. Barnes and Burt (2009) found that liquid draining from food waste from a variety of vegetables had high levels of minerals such as nitrogen, phosphorous and potassium. They also found that the liquid had low nitrites and nitrates and low phosphates which they attributed to the predominantly anaerobic fermentation conditions in their experiments (Barnes & Burt, 2009). Most of the nitrogen present in their samples was in the form of ammonia (Barnes & Burt, 2009). They indicated that due to the low pH of this liquid, it needed to be neutralised by diluting it with water, before being suitable to water plants (Barnes & Burt, 2009).

A practical advantage of using Bokashi compost include that it can be prepared in a much shorter time (about 2-4 weeks) than normal compost (about 6 months) (Jensen *et al.*, 2006:27). In addition, Bokashi generally has a lower cost than traditional commercial fertilisers – because it is made from locally available and low-cost materials (Jensen *et al.*, 2006). An additional benefit of compost made from Bokashi EM is that it does not require very much additional training for its use, and so can very easily be used in place of chemical fertilisers (Jensen *et al.*, 2006).

However, storing food waste raises various health concerns, such its potential for harbouring and spreading of harmful bacteria. If coliform bacteria are found in the waste, faecal pollution (of food, water or surfaces) may be suspected, although this may not actually be the case (Haslinger, 2006). This is because coliform bacteria also include species that do not originate in faeces, and which therefore do not pose any human health risks (Haslinger, 2006). Further testing would be required to determine strains of the bacteria present and therefore whether they are dangerous or not.

12. Complexity and Socio-Ecological systems

a. Complexity and food insecurity

Food insecurity in South Africa has been called a ‘complex social challenge’ (Kahane, 2004; cited in Drimie & McLachlan, 2013:4). The different kinds of complexity that exist in this food security challenge include:

- Social complexity – there are many perspectives and many players;
- Dynamic complexity – because causes and effects are separated in time and space, it is difficult for people to understand the consequences of their not tackling the problem; and
- Generative complexity – problems are developing in ways that are ‘unfamiliar and unpredictable’ (Drimie & McLachlan, 2013:5).

This rapid change in the characteristics of problems means that they need ‘new and unfamiliar solutions’ (Drimie & McLachlan, 2013:5).

b. Complexity and Socio-ecological systems

A socio-ecological system has been described as an ‘ecological system intricately linked with and affected by one or more social systems’ (Anderies, Janssen & Ostrom, 2004:20). Socio-ecological systems are complex – they have many interconnected elements, they are diverse, and they are also adaptive. This means that they are able to learn from experience and to respond to change (du Plessis, 2008). Due to this complexity, socio-ecological systems have emergent properties that the characteristics of these complex properties influence. However, they cannot be reduced to these characteristics or properties (Harding, 2000; in Burns, Audouin & Weaver, 2006).

The complexity of the food system in socio-ecological systems is illustrated by the fact that the link between rising food prices and soil degradation is not being paid enough attention in global food security and other ‘food regime’ discourses (Swilling & Annecke, 2012:140). In order to tackle the food crisis, we need to understand the ‘ecological underpinnings of livelihood systems’ (Drimie & McLachlan, 2013:3). Ecologists can contribute to recognising characteristics that are critical for development to be environmentally and economically viable (de Clerck, Ingram & Rumbaitis del Rio, 2006). This can be done by testing how practical application of ecological theory to development needs can both meet human needs and conserve ecosystems (de Clerck *et al.*, 2006). McLachlan and Thorne (2009) show us this can be done by applying ecological theory to agriculture. These authors suggest a greater effort is needed to bring the focus of agriculture on the need to meet ‘fundamental human needs’ (2009:22). They highlight that this re-focus of agriculture in South Africa will need to consider land reform, equity, human and ecological health and nutrition (McLachlan & Thorne, 2009). In order to work on this focus on ecological health and food production, agriculture will need to operate ‘in partnership with nature’, as well as make

efficient use of ecological services (McLachlan & Thorne, 2009:22). Enhancing and maintaining South Africa's food system will need '... not merely a technical solution, but an approach that recognises the value of ... ecological services that through social interactions and cooperation work with rather than against nature' (McLachlan & Thorne, 2009:20). Through exploration of ecological food waste management, this interface between the complexities of ecosystems services and those of poverty, waste, soil conditions and food production were investigated in this study.

c. Complexity in informal settlements

The dynamics of settlements where slums are located can vary considerably (Misselhorn, 2008). Life and living in informal settlements in South Africa involves a constant tension in the dynamic interaction of factors such as poor housing and service delivery, sanitation, crime, security, unemployment and food access. These interactions are complex and ever-changing. This complexity is compounded because the poorest residents of urban areas are especially sensitive to stressors, such as the 'enormous pressure' of changing food and oil prices, as well as to economic instability (Burger *et al.*, 2009:27). These are some of the numerous factors that affect policy-makers' and city planners' abilities to meet increasing services demands (Burger *et al.*, 2009).

d. Complexity, Poverty and Food Systems

For the first time since poverty levels have been monitored, both poverty rates and the number of people living in extreme poverty in developing regions (including Sub-Saharan Africa) have decreased (UN, 2012). In South Africa, the Living Conditions Survey of 2008/2009 reported that the food poverty line, in relation to food prices of March 2009 was R305,00 (Statistics South Africa, 2013:15). This food poverty line refers to the amount of money an individual needs per month to access a minimum energy intake (Statistics South Africa, 2013:15). In this survey, the percentage of households in South Africa living below the food poverty line was 16,2% (Statistics South Africa, 2013:19).

On a local level, the Stellenbosch Municipality identified the poverty level for households in the area to be the lowest income bracket of R0 – R42 000 per year (Stellenbosch Municipality, 2013:28). Households in this income bracket generally struggle to meet their basic needs (Stellenbosch Municipality, 2013). In 2011, the percentage of households found to be in this lower income bracket in the Stellenbosch area was 19,1% (Stellenbosch Municipality, 2013:28). As we can see, this figure is roughly comparable to the national statistics for food poverty.

Increasingly, the limited (and diminishing) economic opportunities for poor urban residents mean their ability 'to climb out of poverty remains constrained' (Frayne *et al.*, 2009:3). The question is how opportunities can be created using local materials and low levels of technology to reduce the

stranglehold of poverty on these urban populations. In this context, it is critical that we recognise that the 'ability for people to fend for themselves ... (is) ... an asset rather than a hindrance to society ...' (Royden-Turner, 2010:75). A food system that works for the poor can have a positive impact upon health costs, environmental sustainability, employment and the economy (Battersby, 2011a). We need to be cognisant that changes in food systems, in urbanisation levels and in agriculture mean that there are 'significant challenges' to issues of malnutrition (FAO, 2013b:23). Although the problem of malnutrition will evolve, the problems of undernutrition which often occur together with poverty 'will continue to pose a major nutritional challenge' into the future (FAO, 2013b:23).

13. Research gaps

a. Mind the (food 'waste') gap

While food (in)security and UA research has been extensive over the past few decades, there has been a noticeable lack of attention regarding food waste recycling and the recognition and importance of it as a resource for UA production and food security, especially in Southern Africa. Many studies diligently investigate UA and food insecurity in different regions, but they do not often focus on aspects such as household food waste. Furthermore, issues relating to food waste are consistently missed in discussions of poverty, urbanism, waste management and food production. Even the more conscientious literature relating to the localisation of food systems and production infrequently mentions how food waste can be used to make food systems and nutrient resource flows more efficient and ecologically sustainable (see Norberg-Hodge, Merrifield & Gorelick, 2000). These inadequacies and the opportunities which they offer for making cities more sustainable are neatly summarised by McLachlan and Thorne (2009), who indicate that:

'Managing the ecological challenge of urban growth through a food security lens connects rural and urban systems, and also helps to focus production, waste management and environmental stewardship at the local level of the city and its neighbourhoods. In so doing, the ecological footprint of South Africa's growing cities could be better controlled and managed, while economic development related to the food system could bring much-needed employment opportunities to poor urban households' (McLachlan & Thorne, 2009:11).

There are emerging concerns amongst researchers that most UA research and literature is not empirical or scientific. These deficits in research point to the unique opportunity of exploring poverty, livelihoods and food waste management through biological and ecosystems lenses, within the real life context of an under-served informal settlement in South Africa.

b. Research on infrastructure upgrading

Some recent positive developments in the research on construction and infrastructure include descriptions of how poor and under-serviced communities have organised themselves into construction teams and saving schemes. These types of activities allow people to 'develop solutions that ... (they) can manage, finance and build' (Hasan, 2002:200). The kind of research associated with these kinds of activities is only just beginning to emerge. The researcher believes that this indicates that the co-designing, implementation and management of infrastructure upgrading projects are key areas for future participatory research.

14. Discussion

There is little available published literature regarding how the kind of self-organisation for infrastructure construction described by Hasan (2002) has been done for food and organic waste management in informal settlements. Most information of these kinds of initiatives, where they do exist, remains in grey literature. For this reason, quantitative empirical research on biological, social and ecological aspects of food waste in an informal settlement context is needed to bolster the body of published literature itself.

Testing various social arrangements and scientific methods for food waste management and composting (in Enkanini and elsewhere) should give us better insights into the characteristics necessary for effective and successful community waste management in informal settlements in South Africa. It should also allow us to see how closing this resource loop can contribute in real terms to food security. Such insights could include an awareness of factors that contribute to willingness and incentives needed for participation in communal activities which may not necessarily be those which we initially expect. The impact of waste management in informal settlements is particularly relevant because residents' chances of access to regular and adequate domestic waste removal are lowest in these areas. Furthermore, given that residents in marginalised areas are more vulnerable to sickness and disease, the negative health impacts associated with inadequate waste removal in these areas is even more critical.

15. Conclusion

In this chapter, the very real and everyday problem of domestic food waste (kitchen scraps) management in informal settlements and the paucity of research on the topic was framed. The literature review is thematic, and explores topics of poverty, housing, incremental upgrading, food insecurity, food waste, biological food waste management, complexity and socio-ecological systems. These topics are described in the context of how they relate to challenges in densely populated urban areas, particularly in low-income and informal settlements in Southern Africa. They are also explained in relation to the greater context in which they are embedded – the complexities of a failing global food system where closed-loop cycling of resources and nutrients is

not common. The researcher therefore views hunger as ‘... an invitation to make a better world’, and realises that this continues to be the case, despite decades of interventions worldwide (Roberts, 2008; cited in Frayne *et al.*, 2009:39).

Chapter 3: Research design and methodology

“It doesn’t matter how much you want. What really matters is how much you want it. The extent and complexity of the problem does not matter as much as does the willingness to solve it.”

Ralph Marston

1. Introduction

In this thesis, a transdisciplinary methodological approach was used as the primary tool for deepening understanding of some aspects of the complex socio-ecological system of the Enkanini informal settlement and its community. A mixed methodology was used, combining the collection and analysis of qualitative and quantitative data. The transdisciplinary focus of the research assisted in detecting links and relationships between some of the elements of the Enkanini system that may not have previously been acknowledged, or ones that have been underestimated. The research has been carried out following some concepts related to Participatory Action Research, which was used as a tool to highlight various aspects of this case study research.

Individual social and community interactions with food waste have been chosen to assist in the process of gaining a deeper understanding of the complex issues contributing to difficulties of implementing localised food production, and specifically Urban Agriculture (UA), in marginalised settlements in South Africa. This assisted in interpreting the challenges for practising UA in South Africa in particular, as well as in understanding general social and sustainability complexities of the food system as a whole.

The flexibility and adaptability of the research process ensured that it mirrored the uniqueness and informality of the Enkanini community. Taking this kind of approach assisted in the co-development of food waste management innovations that may be better-suited to the developmental, technological, cultural, socio-economic and ecological sustainability needs and aspirations of the community.

2. Methodology approaches

a. Transdisciplinarity

We live in a world where there is rapid change, high uncertainty and ‘increasing interconnectedness’ (Hirsch Hadorn, Hoffmann-Riem, Biber-Klemm, Grossenbacher-Mansuy, Joye, Pohl, Wiesmann *et al.*, 2008:vii). This means there is now an increasing requirement that science ‘contribute to the solution of persistent, complex problems’ (Hirsch Hadorn *et al.*, 2008:vii). These new problems have a new structure in which ecological effects and human actions are ‘so

tightly linked within these problems that the borderline between society and nature ... increasingly blurs' (Jahn, 2008:3). It follows, then, that we will need to think of new types of responses to these new kinds of problems (Jahn, 2008).

One such response comes from the relatively young field of transdisciplinarity. This is a method where scientists in different disciplines work together with practitioners in order to find solutions to real-world problems (Scholz, Lang, Wiek, Walter & Stauffacher, 2006). Transdisciplinary research traverses 'the borders between disciplines and departments, as well as those between scientific knowledge and everyday knowledge ...' (Jahn, 2008:11). Using the transdisciplinary approach for research can help to create 'pools of critical knowledge' which are necessary for dealing with problems (Jahn, 2008:5). This kind of research is needed when the knowledge regarding 'societally relevant problem field(s) is uncertain', when the actual nature of the problem is not agreed upon, or when there is 'a great deal at stake for those concerned by problems and involved in dealing with them' (Hirsch Hadorn *et al.*, 2008:34). Transdisciplinarity has been described as a science that has 'an ambition to go beyond interdisciplinarity', and in such a way that it is able to 'challenge the borders' of science which is traditional (Andr n, 2010:3).

The aims of transdisciplinary research are thus to structure, identify, handle and analyse issues in fields where problems or challenges exist (Hirsch Hadorn *et al.*, 2008:4). In order to do this, Pohl and Hirsch Hadorn (2007; cited in Hirsch Hadorn *et al.*, 2008:4) state that transdisciplinary research has four goals:

- To understand the complexity of a problem;
- To understand the diversity of perceptions of problems from scientific and life-world views;
- To create links between case-specific and abstract knowledge; and
- To work on developing practices and knowledge that help to promote 'what is perceived to be the common good'.

There are essentially three different types of knowledge associated with transdisciplinary research and work which are needed for tackling complex life-world problems. These are:

- Systems knowledge;
- Target knowledge; and
- Transformation knowledge.

System knowledge relates to the understanding of empirical processes and the interaction of factors (Hirsch Hadorn *et al.*, 2008:30). It also includes interpretations of these processes and factors in the life-world (Hirsch Hadorn *et al.*, 2008:30). Target knowledge is related to explaining and working out the need for change, as well as the need for better practices and goals (Hirsch Hadorn *et al.*, 2008:30). Transformation knowledge refers to an understanding of a range of

possible means of acting or behaving in order to change existing practices e.g. socially, technically, culturally and legally (Hirsch Hadorn *et al.*, 2008:30).

Justification for carrying out TD work and research is provided by Burger and Kamber (2003:56), who point out that due to the complexity of social issues, and the unique demands which 'knowledge for societal action' has, stakeholder participation becomes particularly critical. This is because participation is a key element involved in the production of knowledge which is transformational (Burger & Kamber, 2003). Further to this, the actual reliability of scenarios which are made within the context of real-world and complex problems is highly reliant on combining knowledge, perceptions and attitudes of non-scientific participants with scientific analysis (Burger & Kamber, 2003).

The research for this thesis forms part of the Social Learning for Sustainable Food Systems (SLSFS) research projects which were undertaken in 2013. The SLSFS has the objective of responding to challenges in the food system by '... moving beyond traditional problem solving techniques and processes, which are by and large linear and reductionist' (Drimie & McLachlan, 2013:1). Theories on transdisciplinarity encourage looking at how social changes in society can be sustainable because of a well-considered combination of learning, application and research (Drimie & McLachlan, 2013). The complex challenges of the food system need a transdisciplinary approach. This approach needs to facilitate solutions to problems which seem unsolvable, through co-creation and co-learning (Drimie & McLachlan, 2013). This research followed SLSFS methodology in order to '... explicitly engage the complex, non-linear relationships that characterise the food system' (Drimie & McLachlan, 2013:1). This involves identifying and grappling with the problems of the food system which are 'stuck' (i.e. seem to be irresolvable) (Drimie & McLachlan, 2013:2). This has been done in ways which encouraged joint actions and new learning for participants and the researcher. Ultimately, research is based on the fundamental viewpoint that the way we approach a situation will affect how it develops (Drimie & McLachlan, 2013).

All these theories and commentaries on TD sound very attractive to both researchers and practitioners. However, taking this kind of approach to research has some significant challenges and limitations, which one needs to be aware of before embarking on any kind of TD process. Andrén (2010) warns us that we should not be surprised that TD research raises criticisms. She cautions that some people, on first impressions, will consider TD work to have a 'radical and challenging approach' which has 'revolting ideas' and which involves experimentation with methods (Andrén, 2010:13). Andrén (2010:14) cleverly summarises the challenges of TD work by describing it as being an approach that, apart from involving real-world problems, has 'no easy truths' and 'high stakes'.

Andrén (2010) goes on to say that TD work requires ethical, political and normative judgements. She questions whether TD researchers should be the ones who are required to make these judgements. If so, then Andrén (2010) continues by asking whether the researcher is then actually doing research or not. This shaky ground is described as something which may make the TD approach 'look fuzzy and dubious' (Andrén, 2010:3). However, she argues, and I agree, that this is exactly what makes TD research relevant for research on sustainable development in general. She continues by asking how one can do 'good research', what she refers to as 'research that will matter' (Andrén, 2010:3).

According to Hirsch Hadorn *et al.* (2006), TD research needs to include the evaluative, empirical and instrumental aspects of problems, which are referred to as target knowledge, systems knowledge and transformative knowledge. However, Andrén (2010) argues that this may all sound very well, but it is likely to be very demanding or even unrealistic to think that a research process can achieve all these things.

A further frustration of the TD approach is that research which involves genuine participation in the process is often very time-consuming and does not seem to result in empirical publications at the same speed or frequency as research in a single discipline or of a certain analysis level (Christens & Perkins, 2008). Similarly, it is often hard to explain action research projects to bodies or organisations such as funders, review boards and even organisations and communities who one hopes to work with on the ground (Christens & Perkins, 2008).

As the TD researcher becomes an active component of the research field, they will need constantly reflect on their role (Andrén, 2010). This is because, if present unsustainability is seen as being something which is linked to deep structures within society, it must be lodged within our individual ways of thinking too (Andrén, 2010). This provides further justification for the need for self-reflection, and this makes it a key element for any kind of progressive TD research (Andrén, 2010).

In addition, TD researchers will need to 'dare to climb down from the ivory tower and work together with – and not above – people' (Andrén, 2010:4). Being a TD researcher requires a tricky mix of being dedicated to but also 'distanced and balanced' from their research (Andrén, 2010:8). Furthermore, TD research implies and requires an enormous amount of engagement and personal commitment (Andrén, 2010). On top of all this, TD researchers need to be able to clearly show their ability to reflect on their work, not in a few aspects of it, but in all aspects of the research process (Andrén, 2010). The flexibility needed in TD research should be equated in some way by consistency, to avoid the risk of being perceived to be confused, fragmented or arbitrary (Andrén, 2010).

An additional difficulty of TD research is that because it aims to challenge the contemporary way of creating 'normal' science, it will need to have a high degree of innovation (Andrén, 2010:6). In addition, in order for TD research to be good, it needs to formulate new ideas which not only relate to how research problems and methodology are framed, but also on how results are used and disseminated (Andrén, 2010). Yet another complication of TD research is that science cannot escape the influence of politics and power (Andrén, 2010). This means that TD researchers will need to accept a critical task - that they will invariably become enmeshed or connected to political and power spheres (Andrén, 2010). Finally, following the advice of Max-Neef (2005:12), we need to remember that although approaches of TD are needed, TD remains an 'unfinished project', about which we still need to investigate and discover many things. Therefore, TD can be thought of as being two things – a project and a tool (Max-Neef, 2005).

b. Action Research and Participatory Action Research

Action Research (AR) refers to the application of theories 'directly in the field' (Raelin, 1997:21). The concept of AR arises from the straightforward idea that people learn better 'when working on real-time problems occurring in their own work setting' (Raelin, 1997:21). Significantly, in 1979, Fals-Borda said that it was a 'privilege' to live with the opportunity to 'confront processes of radical, social transformation' (Fals-Borda, 1979:33). In addition, Fals-Borda (1979) went on to say that, scientific communities had a responsibility to interpret these transformation processes in ways that allow them to obtain information to bring about change.

Some recent positive developments in AR for construction and infrastructure include descriptions of how poor and under-serviced communities have organised themselves into construction teams and saving schemes. This kind of AR allows people to 'develop solutions that ... (they) can manage, finance and build' (Hasan, 2002:200). Hasan's (2002) example refers to how residents of a slum in Karachi, Pakistan, organised themselves for construction of sanitation infrastructure. Hasan stressed, however, that it was acknowledged from the start of the project that '... people would require technical guidance and managerial support to implement the technical solutions ...' (2002:201). Importantly, Hasan also pointed out that 'technical and social research' is needed as a 'prerequisite' in order for this guidance and support to occur.

Participatory Action Research (PAR) is a form of research that challenges the traditional and top-down model for research that is elitist, and instead it works on 'advancing human welfare' (Gaventa, 1991; Reason, 1994; Whyte, 1991; in Barbera, 2008:143). The methodology of PAR allows aspects of social dynamics, interaction and partnerships in the process, and also recognises that there must be a relationship between the participants and the researcher (Fals-Borda, 1997; Glazer, 1972; Padgett, 1998; Smith, 1997b; Whyte, 1991; in Barbera, 2008).

A principal element and value of PAR is trust (Barbera, 2008). The role of trust is extensive in PAR because the research involves more than just talking to people (Barbera, 2008). Rather, PAR involves working with participants intimately, and this can sometimes be ‘... in situations that question the status quo’ and where risk taking occurs (Barbera, 2008:144).

One of the main objectives of PAR is to open up knowledge which is useful to the process of ‘liberation ... of oppressed and vulnerable populations’ (Barbera, 2008:143). These populations play an integral role in the process of highlighting knowledge related to the realities they live (Barbera, 2008). PAR has been described as aiming to assist people in freeing themselves from social conditions which are ‘irrational, unproductive, unjust, and unsatisfying’ (Kemmis & McTaggart, 2005:282). Thus, PAR is a process where people aim to ‘contest and reconstitute irrational, unproductive (or inefficient), unjust, and/or unsatisfying (alienating) ways of interpreting and describing their world ...’ (Kemmis & McTaggart, 2005:282).

The PAR approach allows the research process to be flexible. This is particularly relevant in the context of informal settlement research, which can involve unpredictable social and environmental situations. This flexibility has been used in this research to mirror the informality of the settlement, and has allowed data to be collected ‘as and when (it was) ... needed rather than before the research’ (Ng & Hase, 2008:159). This constant monitoring was particularly useful in terms of catering for the changing needs and evolving characteristics of the case study in this research.

In PAR, the participation of outsiders or researchers should be seen to be ‘within the spirit of partnership’ (Barbera, 2008:145). These outsiders have an interesting but difficult role to play, as they are actors whose positions lie somewhere on a continuum between ‘power and possibility in society’ (Finn & Jacobson, 2003; cited in Barbera, 2008:145).

Participatory Action Research involves the action of ‘reaching out’ from the details of specific and local studies and localised perspectives and understanding, in order to connect to outside perspectives and theories and discussions (Kemmis & McTaggart, 2005:283). In this way, these authors suggest that this exposes people involved to insights and practical ways of doing things that may assist them to develop ideas for how things can be transformed (Kemmis & McTaggart, 2005). Similarly, PAR is an opportunity for ‘reaching in’ from these new and different perspectives and theories, in order for practitioners to have a ‘critical grasp’ of the challenges which they face in their own situations (Kemmis & Taggart, 2005:283).

Similarities can be drawn between characteristics of SL (see section 7 of Chapter 2) and adaptive management to those of PAR (Mackenzie, Tan, Hoverman & Baldwin, 2012). These include, for example, that adaptive management is a process that involves ‘collective self-reflection’ that

occurs via dialogue and interaction of a diversity of stakeholders (Fernandez-Gimenez, Ballard & Sturtevant, 2008:6). Also, although SL can occur in various ways, its basic requirement is that it is dedicated to meaningful dialogue (Campel, 2000; in Mackenzie *et al.*, 2008; Kilvington, 2007). There is also evidence that SL approaches have enabled participants to negotiate the differences in knowledge of stakeholders, and to co-produce knowledge (Kuper, Dionnet, Hammani, Bekkar, Garin & Bluemling, 2009). Mackenzie *et al.* (2012) show how PAR can be used for improving water planning and management. They indicate that PAR lessons are useful for planners, especially ones trying to understand how both technical and community knowledge 'can be better harnessed and integrated' (Mackenzie *et al.*, 2012:20).

The incorporation of SL into PAR can also be considered as part of an iterative learning and action spiral or cycle. This process of learning and acting together for change is depicted in Figure 2.

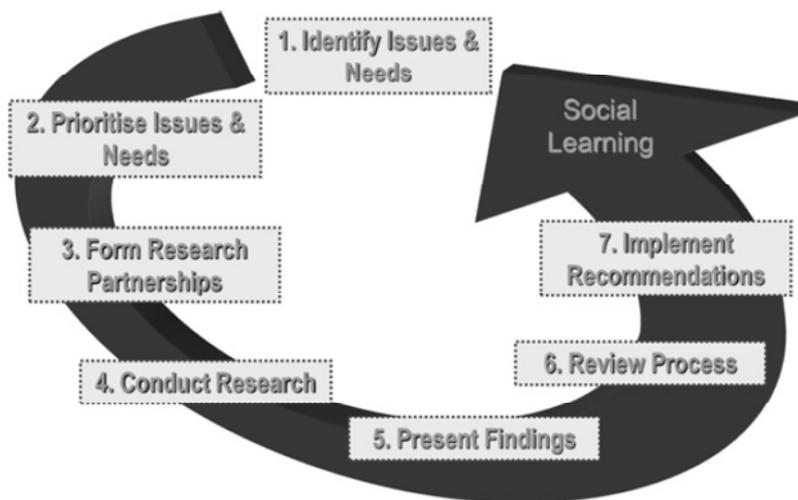


Figure 2: Participatory Action Research and the adaptive cycle (from Mackenzie *et al.*, 2012:17).

One of the main challenges in PAR is the wide range of meanings of PAR itself, including how terms such as 'PAR', 'participatory research' and 'action research' are used interchangeably (MacDonald, 2012:40). Also, the fact that PAR traditionally involves community members as part of the research team, this can become challenging, as they may find it difficult to keep up their commitment to the project over time (Gillis & Jackson, 2002; in MacDonald, 2012). Furthermore, before PAR research can begin, any issues related to inequality in power balances as well as setting up of equal relationships between those involved need to be addressed (Gillis & Jackson, 2002; Maguire, 1987; in MacDonald, 2012). Therefore, all of the research team members need to be both responsive and sensitive to the different kinds of leadership that may be needed in the project at different times (Gillis & Jackson, 2002; in MacDonald, 2012).

A further requirement and challenge for PAR is that those participating need to be made aware that it is a time-consuming activity and the research team needs to be committed (MacDonald, 2012).

Additionally, education is needed in order for all involved to participate in the research (MacDonald, 2012). Another difficulty with carrying out PAR is that the researcher needs to be able to access the community which will be investigated – this may be a very real challenge, especially if the community is unfamiliar to the researcher or if they have a different cultural background (MacDonald, 2012).

From an academic point of view, one of the challenges which PAR researchers may face in using PAR methodology (similar to those following TD methodology) is that they may have to prove their legitimacy to other academics, who may be ‘more conventional’ or ‘unused to working with open-ended research designs’ (MacDonald, 2012:41). Additionally, PAR has been described to be ‘context specific’, ‘fluid’ and ‘context-centred’ (Mackenzie *et al.*, 2012:13). Although these are indeed strengths of PAR, they may also be seen as weaknesses, because if projects are seen to be overly context-specific, then the reproduction of their outcomes elsewhere may be limited. Similarly, if a PAR process is too fluid (i.e. unpredictable or changeable), this may result in negative consequences such as unwillingness of stakeholders to participate, lack of willingness of funders to invest, and extreme pressures and stress on researchers or facilitators wishing to manage the process itself. Finally, we need to remember that although the TD, participatory and action-orientated research approaches are appealing for many reasons, they are also very demanding and ambitious (Andr n, 2010).

c. Practical Manifestations of Transdisciplinary, Social Learning and Participatory aspects in thesis

The researcher decided to engage practically with some aspects of SL and TD theory, in order to work with participants to produce a physical manifestation of their efforts in food waste collections. She did this by considering the literature and formulating a plan of action that she felt seemed to emulate this. For example, SL can occur at different levels among individuals, social units, communities of practice and organisations. These levels include interactions of engagement, imagination, and alignment (Wenger, 2000). Engagement involves doing things together, talking and making artefacts (representations of learning, such as maps and other documents). Imagination refers to the creation of an image of our communities, our world and of ourselves (Wenger, 2000). Alignment is the need for ensuring that our activities are sensitive, contextual and in line with or congruent to other activities or processes, ‘... so that they can be effective beyond our own engagement’ (Wenger, 2000:228).

Thus, based on these concepts and methods of engagement, imagination and alignment, the researcher decided to collaborate with two other TD students in the Collective group to brainstorm ways of creating this practical manifestation or artefact for the collections. This interaction and engagement was enabled by carrying out a banner painting workshop for participants where they

all participated in a public art project. The idea of introducing public art into aspects of the project was explored quite early on in the research process, as it is considered to be both aligned to the community and participatory in nature. This is because residents of the community were involved in the creation of the artefact practically (by painting it) and logistically (by participating in food waste collections). Also, these participants were able to use their imaginations when painting on the banner, and in so doing, created unique representations of themselves and their households. The artefact they painted was also a visual way for these participants to value and remember their roles in the food waste collections.

The art workshops were co-ordinated by Susan Immelman, a Master's student in Fine Art at Stellenbosch University. Her work focuses on creating spaces for residents to express themselves (using tools such as storytelling) through the use of drawing, public art and craft. The workshop was held over two of the normal collection days in June 2013 (both days were Saturdays, between 9am and 12pm). The workshops were also co-ordinated with the help of another Collective member, Gwendolyn Meyer, a Masters' student studying Sustainable Development. Gwendolyn's interests lie in mark-making and design, as well as public information dissemination and education through co-produced artistic media.

3. Sampling

Results for this thesis include empirical qualitative data from a number of sources, namely:

- food waste collections (in 2013);
- food collection participant interviews (in 2013);
- laboratory testing of food waste, soil, compost and processed food waste residue samples (most from 2013 project, some compost samples were from 2012 project);
- participatory art workshop and photography for collection participants; and
- interview with gardener in Enkanini; and
- interactions with farmers around Stellenbosch for collecting soil and compost samples.

a. Location of research

Figure 3 indicates the Enkanini settlement in relation to the nearby Kayamandi settlement and Stellenbosch, in the Cape Winelands of the Western Cape.

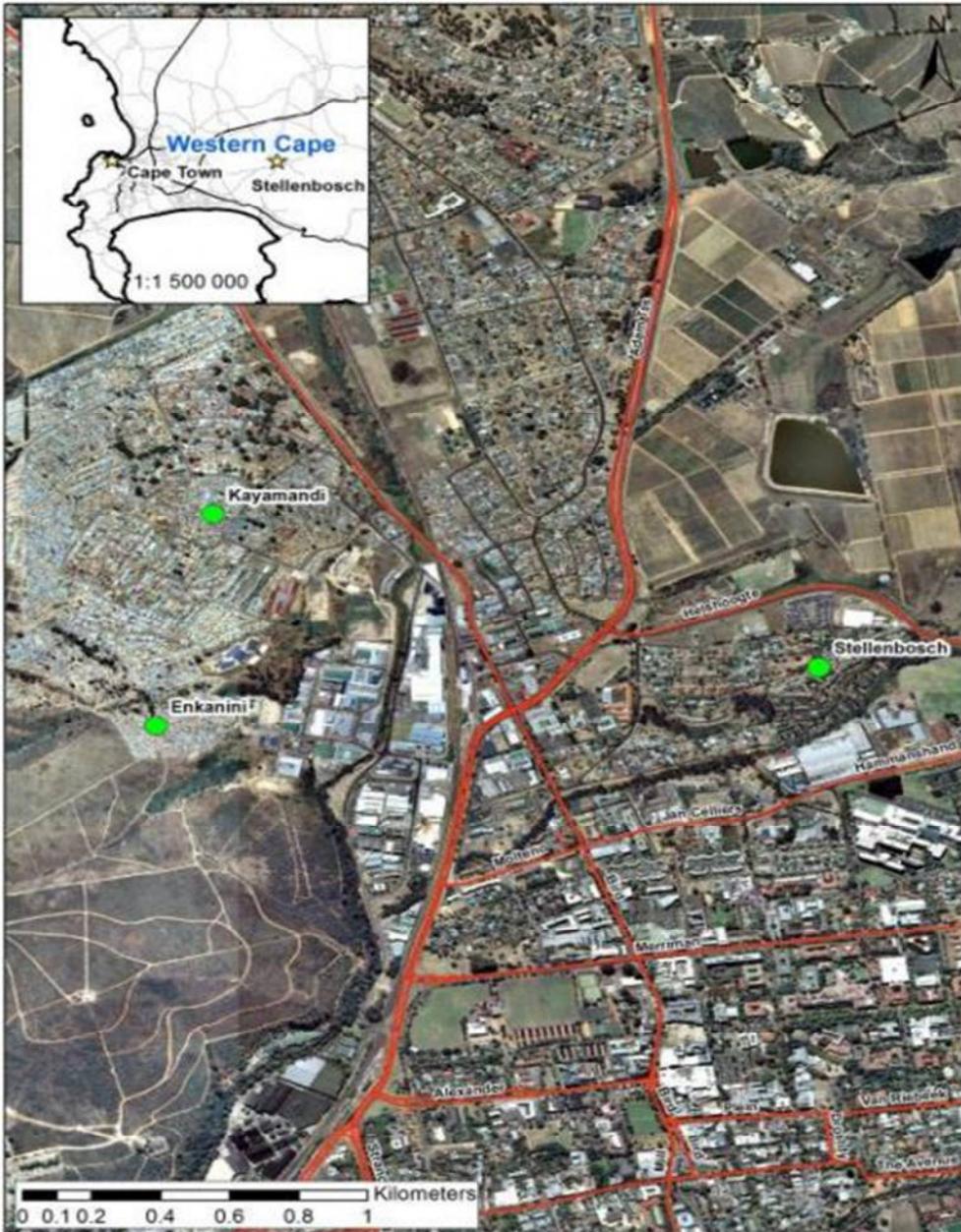


Figure 3: Location map of Enkanini, Stellenbosch (Source: David Ogier, 2013).

A map indicating the different residential zones in Enkanini is presented in Figure 4. The Bokashi food waste drop-off centre which was the main collection point for collections in 2013 is labelled as 'Bokashi shack' with a star symbol in Zone E.



Figure 4: Zones in Enkanini, and location of the Bokashi food waste drop-off centre (Source: Adapted from map from CORC, 2012).

b. Players involved in waste collection in Enkanini – project geography

The Stellenbosch Municipality is supposed to collect domestic waste from Enkanini's skips on a weekly basis. However, due to various complications and logistical and budgetary limitations, this service is irregular. This waste is taken along with domestic waste from other areas in Stellenbosch to the Devon Valley landfill site. Residents are sometimes provided with black refuse bags by the municipality for their waste collection, but this does not appear to be a regular service either.

Informal waste pickers can sometimes be seen at the waste skips in Enkanini and walking around the settlement, collecting various types of waste. They also move around other parts of Stellenbosch during municipal waste collection days. They take their salvaged waste (generally cardboard, metal and plastics) to exchange with recycling operations in the area for cash.

During the 2013 food waste collection project, two key players were involved in collecting and removing the food waste from Enkanini. The first player was Cobus Smit, a freelance composting consultant and permaculture gardener, who works at the Paarl Nursery. He would come with a colleague from the nursery to collect and load the food waste drums on an ad-hoc basis, when all available drums were full. He used the waste on a few occasions in composting workshops which

he held around Stellenbosch for permaculture students. However, most of the waste he collected went to Paarl Nursery, where they used it in their large compost heaps (intended for later use in the nursery plant containers for sale) and in a few vegetable bed displays at the nursery.

The second group of players involved in the collecting the food waste during the 2013 project were Agriprotein. This is an experimental agricultural enterprise, associated with Stellenbosch University. Agriprotein's operations are based on a farm in Elsenberg, about 15km from Stellenbosch. There, they run various experiments related to the growth and production of Black Soldier Fly (BSF) larvae (*Hermetia illucens*), which feed on a wide variety of waste types, including food (kitchen scraps) and human waste. These larvae can be fed to agricultural stock such as chickens and fish, which thrive on their high protein content.

At the beginning of the 2013 project, the researcher was required to drop off the food waste at Agriprotein's operations, although they later agreed to collect the waste using their own labour and vehicle. Cobus came on a few occasions to collect the waste early on in the project. Over time, the researcher attempted to split the frequency of collections carried out by Cobus and Agriprotein, so that each of them came to collect the waste drums every fortnight. This became an ongoing task, even after the data collection period for this 2013 case study was over. Later in the year, for various logistical reasons and constraints, it was not always possible for these two players to come at the same or regular frequency. In general, after the data collection period, Agriprotein came more frequently than Cobus, as they had more frequent access to vehicles.

Both Agriprotein and Paarl Nursery collected the food waste for free throughout the 2013 project. In addition, they did not pay a fee for their use of the food waste. Both parties were given keys to the drop-off centre in Enkanini, in order to streamline the logistics of collections, and co-researchers were also given keys in order to assist with collections when needed.

The Solid Waste management department at the Stellenbosch Municipality is aware of Agriprotein's operations and the potential of the BSF larvae to manage food and organic waste on a large scale. The department has also been in contact with ProBiokashi (Pty) Ltd. who were the suppliers of the waste management technology, Bokashi EM. However, the municipality does not currently have any waste management projects running in the area which involve these two players. However, it is hoped that the municipality's interest in the research from the 2012 and 2013 food waste collection projects in Enkanini will continue, and in so doing, provide them with a basis for starting up similar projects or larger scale waste transfer stations in the area.

Figure 5 indicates the location of the Paarl Nursery and Agriprotein in relation to Enkanini.

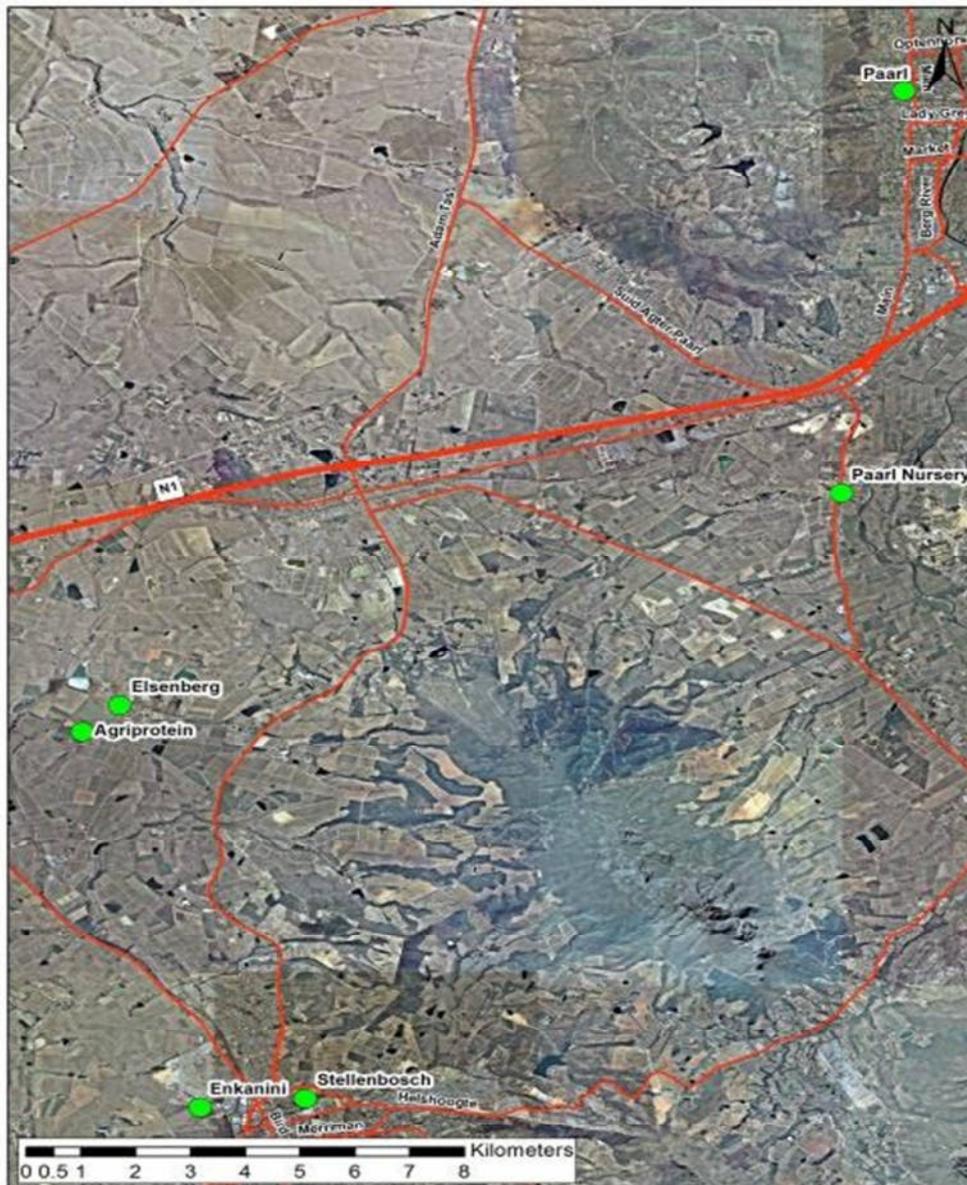


Figure 5: Locations of Paarl Nursery and Agriprotein in relation to Enkanini and Stellenbosch (Source: David Ogier, 2013).

c. Participant Interviews from the extended Bokashi pilot project in 2013

Structured surveys for interviewing participants were designed by the researcher, with the assistance of co-researchers, to ensure that questions were representative and appropriate both for research purposes, and to Enkanini residents. These surveys were conducted by co-researchers and were translated into Xhosa wherever necessary. They were carried out with willing participants on several collection days between May and July 2013. A total of 11 of the possible 56 participants were interviewed, which is a sample size of almost 20% of the current number of participants in the project.

d. Waste data and laboratory testing of food waste, soils and compost

The Stellenbosch Municipality waste characterisation study and the 2012 Bokashi food waste pilot project data were examined briefly to understand food resource composition and flows around the settlement. Investigation of composting strategies was done by observing the everyday interactions of residents and using this to inspire experimental interventions appropriate to the low-technology and limited space context of Enkanini. The research practically tested a simple composting method that can be done *in situ* in informal settlements, which can be localised, with little or no need for excessive or specialised outside inputs.

The compost samples tested in this research came from the following sites:

- Compost from a Spier Wine Farm compost heap near Lynedoch in Stellenbosch ('Spier compost');
- Vermicompost from Eric Swarts on his organic farm in Lynedoch ('Eric vermicompost');
- Compost made in a crate during the pilot project of 2012 ('Centre crate compost');
- Compost made with and without Bokashi-treated food waste in the 2013 collection centre in rotating drums ('Bokashi shack compost');
- Compost from Cobus Smit used in vertical pallet gardens during pilot project of 2012 ('Centre compost'); and
- Compost from Knorhoek Wine Farm used in their vegetable garden ('Knorhoek compost').

Figure 6 indicates the locations of compost samples taken for testing in this study.

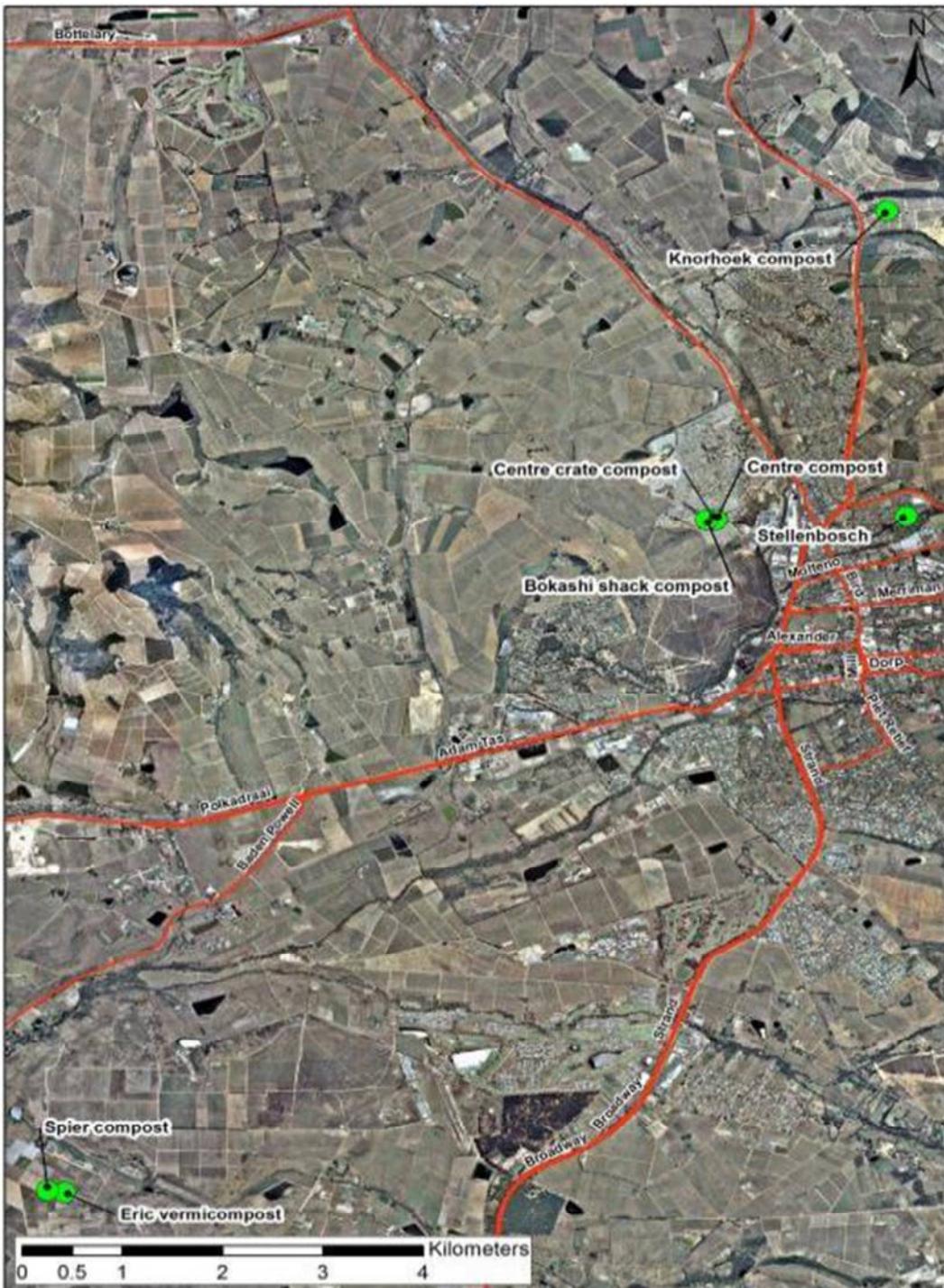


Figure 6: Locations of compost samples tested (Source: David Ogier, 2013).

The soil samples tested in the research came from the following sites:

- Soil from inside and adjacent to vegetable beds at the Legacy Centre food garden in Kayamandi ('Legacy Centre');
- Soil from inside and adjacent to vegetable beds at Polla Park in Enkanini ('Polla Park');
- Soil from inside and adjacent to vegetable beds at Victor Mthelo's house in Enkanini ('iShack');
- Soil from an area just outside the 2013 food waste collection shack in Enkanini ('Bokashi shack soil');
- Soil from the site of the new Research Centre in Enkanini ('Research Centre soil');

Figure 7 indicates the locations of soil samples tested in this research.



Figure 7: Location map of soil sample sites (Source: David Ogier, 2013).

Laboratory tests were done on all soil and compost samples for minerals, heavy metals, nutrients, pathogens and bacterial activity. Similar tests were done on some of the food waste collected during the 2013 project in Enkanini, as well as on some of the liquid draining from this food waste. All samples were tested by an independent laboratory, BEMLAB (Pty) Ltd., in Strand, Cape Town. Advice on interpreting test results was also provided by scientists at BEMLAB.

Some of the samples were collected by assistants from BEMLAB, whilst others were collected by the researcher at a later stage. All samples obtained for laboratory testing were treated in the most practical way possible to ensure that they were collected, protected and preserved rigorously. All test results were shared with or explained to landowners or participants who provided access to samples. If any untoward or negative results were discovered, these were shared as quickly as possible with the relevant participants or landowners. These participants were also given suitable recommendations for managing the implications of the test results, where necessary.

4. Data collection

Data for this thesis was collected from the continued pilot project that ran in 2013 from March to July 2013. The data collected at this time was primarily of an empirical and quantitative nature, though some data was qualitative due to the open nature of semi-structured and participant interviews, as well as due to the research following an overall transdisciplinary approach.

The main objective of data collection was to increase the amount of empirical and quantitative data on safety and quality of food waste generated in informal settlements, as well as qualitative data on social perceptions and stigma relating to food waste and UA practices.

Qualitative data for the research included observations of and discussions with participants in all interviews and experiments. Some data is of an ethnographic nature due to *in situ* interactions with and observations of informal settlement residents in their home environments. The interview with the individual growing food in Enkanini was qualitative as it was an open and informal discussion.

In order to determine the status quo of Enkanini's food production potential, it was first necessary to establish what the existing soil conditions were in the area, as well as if or how much it needed to be improved for successful and healthy local food production. The first set of soil samples were obtained with the professional assistance of scientists from BEMLAB laboratories, who brought all sampling equipment and materials necessary for the sampling. The researcher arranged sampling logistics, and one of the co-researchers was present to assist in liaison with residents, as well to observe the sampling itself. For secondary soil sampling, there was no need for equipment, and

after having observed the BEMLAB scientists, the researcher was able to adequately replicate their methods of sampling with simple tools and materials.

5. Research strategy

The research strategy consisted of:

- Carrying out preliminary and un-structured conversations with current transdisciplinary researchers and co-researchers in the Transitions Collective group;
- Participating in informal discussions with SLSFS researchers, as well as with researchers in the group specifically involved in Urban Agriculture projects and research;
- Going on site visits and having short discussions with individuals and organisations running UA projects and enterprises in other informal settlements around Cape Town;
- Conducting a preliminary literature review to inform the research question and to understand the local context;
- Formulating the main research question, sub-question and research objectives;
- Doing a more detailed and thematic literature review, using a combination of conceptual and narrative approaches as defined by Petticrew and Roberts (2006);
- Carrying out a further literature review to refine research approach and methodology;
- Analysing the results from the Bokashi food waste pilot project run by Vanessa von der Heyde (with the support of Stellenbosch Municipality and ProBiokashi) in the last quarter of 2012;
- Continuing the food waste collections in Enkanini from March to July 2013, following the structure of von der Heyde's 2012 food waste collection pilot project;
- Collecting data from food waste collections in 2013 relating to weight, storage and recycling of food waste;
- Carrying out container composting experiments, both with and without Bokashi-treated food waste collected from Enkanini in 2013.
- Sampling soil and compost from around Enkanini and nearby farms / gardens,
- Sampling food waste collected during 2013 operations as well as compost made in the container composting experiment;
- Sampling residue from food waste processed by Black Soldier Fly (BSF) larvae at a processing facility outside Stellenbosch;
- Sending all soil, compost, food waste and residue samples for laboratory testing for nutrient and mineral content, bacterial activity and heavy metal contamination levels;
- Co-ordinating structured surveys (interviews) with a sample of volunteers from the 2013 case study of Bokashi food waste collection participants;
- Leading an informal and semi-structured discussion with a resident already growing his own food in a garden in Enkanini;

- Considering alternative options for food waste management in Enkanini, including site visits to other food waste recycling enterprises near Stellenbosch;
- Analysing food waste collection and laboratory testing data;
- Reviewing options for up-scaling food waste collections in Enkanini;
- Evaluating potential for food waste collections in Enkanini, linking this to potential options for local food production in Enkanini;
- Evaluating appropriateness of different potential food waste management options in Enkanini;
- Providing suggested phased planning options for up-scaling Enkanini collections.

It must be noted, however, that although this strategy appears to be linear, at any one time of the research process, more than one activity was being carried out, and so this was more of an iterative process than a linear one. The points of the strategy have presented in a linear form for simplicity.

A summary of the research strategy is illustrated in Figure 8.

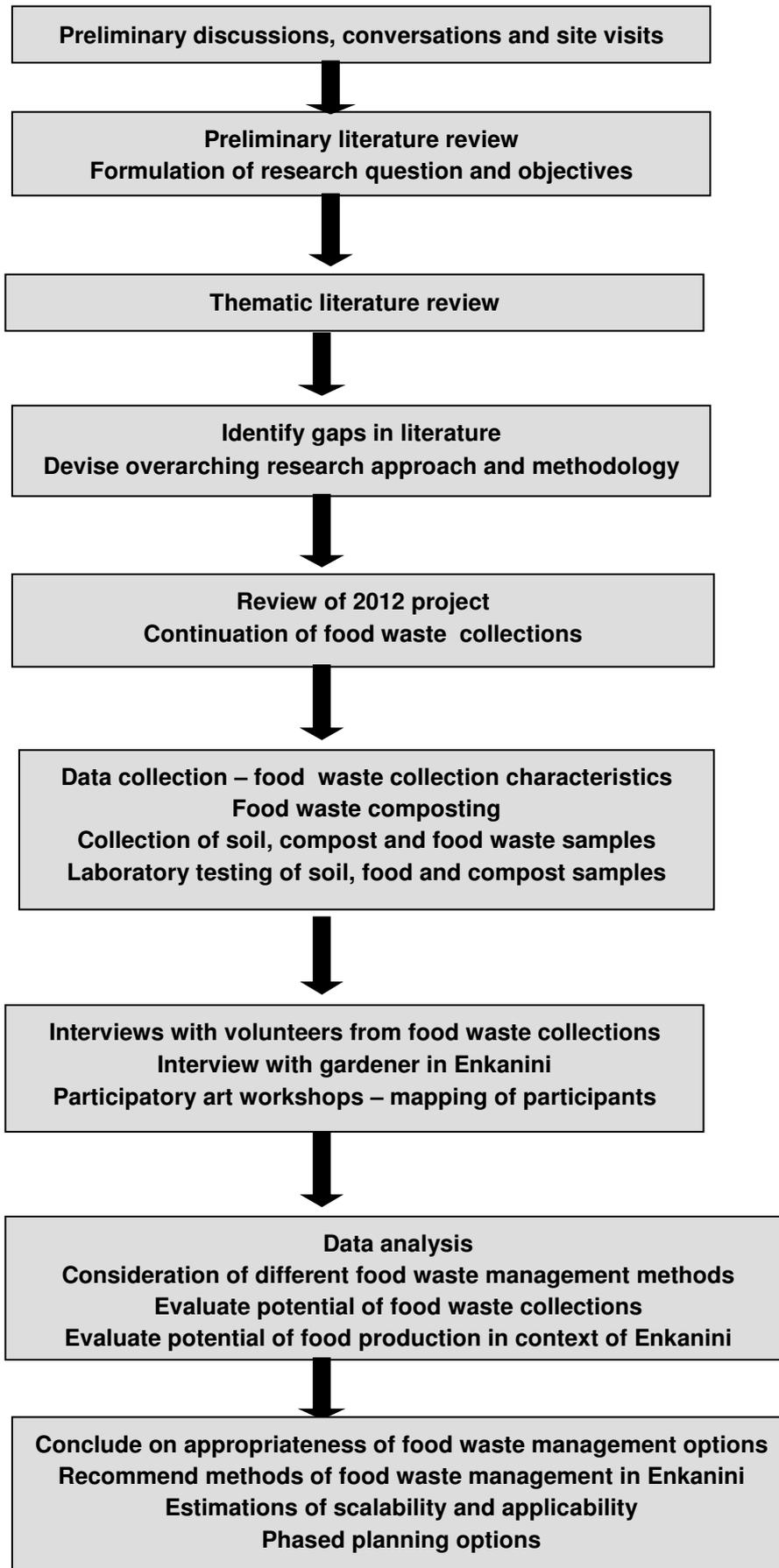


Figure 8: Strategy of research (Source: Author, 2013)

6. Literature review

The literature review process was simultaneously systematic and intuitive. Reference to literature was generally done throughout the research timeline, with a special focus on its guiding features at the beginning and end of the thesis write-up process.

The main literature review followed a systematic and themed search of academic journals and grey literature in English. These themes include the following aspects, with a focus on South and Southern Africa:

- Informal Settlement Upgrading (ISU);
- Urban nutrition and food insecurity in southern Africa (particularly South Africa);
- Urban Agriculture (UA) and food production in Southern Africa (again, focussing on South Africa);
- Urban over-, under- and malnutrition (with a focus on poor urban areas in South Africa);
- Food waste challenges and management, composting and closed-loop resource cycles;
- Transdisciplinarity;
- Co-generation of knowledge;
- Social Learning; and
- Complexity and systems thinking for socio-ecological systems.

7. Composting

a. Methods used

The idea of applying *in situ* upgrading to the current food waste collection activities and to Enkanini's soil quality emerged early on as possible research directions, in order to extend the initial pilot project of 2012. These ideas were explored through the introduction of composting of Bokashi food waste at the waste drop-off centre in Enkanini.

In this case study, the potential and practical applicability of container composting was explored as an option for recycling the food waste collected in Enkanini. Container composting refers to the restriction of composting processes to a closed container, in this case large rotating drums with lids were used. The motivating factors for choosing this container design and method were:

- the need to test and demonstrate a composting method which was relevant to the context of limited open spaces in the settlement;
- the need to demonstrate a method in which local materials could be used (both in design of containers and in production of compost); and
- the need to use a composting method which prevented access of vermin to food waste in compost.

The composting for this case study involved a combination of two processes, that of anaerobic fermentation and aerobic decomposition. The technology which was chosen to assist in this process of fermentation of food waste was Bokashi Effective Micro-organisms (see Chapter 2). Food waste was first treated with Bokashi EM and stored, which allowed it to ferment anaerobically. Then, some of this food waste was mixed with other composting ingredients in the aerated rotating compost drums, thus exposing the food waste to conditions for aerobic decomposition.

b. Composting drums

The composting drums had a capacity of about 200 litres. These drums were attached to a frame which allowed them to rotate when pushed. They have air holes drilled on the top and bottom. This drum design was chosen because it allows for aeration of the compost, as well as fairly easy access for removing compost when it is ready (wide sliding lids on top). Most importantly, the drums were well-sealed which meant rats and other pests were not attracted to compost ingredients (which would have created management problems in the collection shack itself, but also problems for neighbours). Another advantage of the design of the drums is that they are re-useable for other similar mixing or storing activities, making them very versatile in the informal settlement environment.

Figure 9 illustrates the design of the composting drums (green drums on left of image). It also illustrates a typical Saturday morning at the Enkanini food waste collection centre, when collections were done.



Figure 9: Rotating composting drums at a food waste collection day (Source: Author, 2013).

Figure 10 illustrates the sliding lids and air holes on top of the green rotating drums in more detail.



Figure 10: Detail on top of green rotating drums indicating sliding lid and air holes (Source: Ivan Volschenk, 2014).

Participants all had a pair of white 25 litre buckets, with one fitting inside the other (see white buckets on right of Figure 9). The internal bucket had holes drilled in it which allowed any liquid from food waste to drain separately to the food waste. This meant that liquid food waste could be separated at the household source (and discarded to reduce weight of buckets), or collected at the main waste collections if necessary. The internal bucket had a lid which prevented access to food by vermin. The collection participants brought their buckets of waste on Saturdays, and they waited for them to be emptied and washed by co-researchers and the researcher. Participants were instructed at the beginning of the pilot project of 2012 that they could put both cooked and uncooked food waste of all types (including bones) into their buckets, and that they should not put materials such as plastics and metal into the buckets. They sprinkle a little Bokashi EM in between the layers of food waste as they collect it.

The composting materials were weighed and placed in the two green rotating drums. The first drum was considered to be the actual experiment for food waste management, as it contained the Bokashi-treated food waste together with other composting ingredients. The other drum was the 'control' drum, which did not contain any Bokashi-treated food waste, but had the same composting ingredients as the first drum, and in the same quantities. Materials were placed in layers in the drums, and some water was added at the end. The Bokashi-treated food waste that was used in the experimental drum had been fermenting for about one month in a different storage drum prior to its being placed in the experimental compost drum. Both composting drums were filled on the same day, on a single occasion, and were turned on that day when all materials had been added.

On the first day of the composting experiment, when both the experimental and control drums were filled, they were initially kept in the sun to warm their contents. The drums were turned on a weekly or fortnightly basis over a period of ten weeks. For the duration of the experiment, the drums were kept inside the collection shack, for security reasons.

As the drums were not moved out of the shack into the sun for the rest of the experiment duration, the compost mixtures were subjected to the temperature variations which most Enkanini residents experience within their shacks. Given that the shack where collections are done is not well-insulated, it was presumed that the temperatures in the shack were similar to those outside. This is also based on findings from the thermal comfort analysis done for the iShack project (see Keller, 2012). In that study, it was shown that the outside temperature is the main controlling factor influencing the temperature inside shacks. The average high and low temperatures of Stellenbosch over the period when composting was carried out ranged between 6 - 19°C (Weatherbase Website, 2013). This meant temperatures were generally cool during the experiment, which in turn

meant that biological activity (such as of fermentation and decomposition activities of effective micro-organisms and bacteria) in the compost was probably quite slow or significantly reduced.

c. Materials used

Composting materials used in both composting drums included:

- Garden clearing greens from Spier Wine Farm grounds (dry and green grass and weeds);
- Small chips from alien clearing on the Spier Wine Farm which consisted of partially dry chipped branches mixed with green leaves from invasive alien trees such as Port Jackson (*Acacia saligna*) and Black Wattle (*Acacia mearnsii*);
- Loam subsoil from Research Centre excavations in Enkanini;
- Compost from Spier Wine Farm (semi-organic);
- Nguni cattle manure from Eric Swarts (organic farmer working adjacent to Spier Wine Farm); and
- Water.

8. Ethical clearance

Ethical permission for carrying out this project was received from Stellenbosch University in April 2013. Ethical permission forms were signed and obtained from landowners and participants involved in soil or compost sampling. Verbal permission was obtained from them where it was not logistically possible to obtain signed forms. Participants in the food waste survey also signed ethical permission forms. All participation was voluntary and participants or landowners could choose to stop interviews (or sample testing) at any time. The results of soil laboratory tests were shared with landowners as soon as this was possible, and they were encouraged to ask any questions about the results if they had any. These participants were advised if any untoward or potentially risky results were found in their samples, and how to manage these risks, where applicable.

All interactions related to collection participant interviews were conducted entirely by co-researchers, who briefly explained who the researcher was and what the research was about. The researcher explained the permission forms to the co-researchers, who then explained them in Xhosa to participants. Interviews with participants were conducted in the food waste collection site, so interviewees could see all the equipment and materials involved in the research and collection project.

The interview on food gardening conducted with “George” from the garden location called Polla Park was done with the assistance of two of the co-researchers. “George” was directly interviewed in English by the researcher. One of the co-researchers was also present at the time of the interview. The researcher decided to give “George” this pseudonym in order to maintain a certain

level of anonymity in the research. This was because she felt that having declared where his vegetable garden was situated (by naming it and placing it on a map in her research) was enough detail for the purposes of her research.

9. Participation

Composting and waste management innovations were done by building on methodology and investigations carried out by Vanessa von der Heyde in the 2012 pilot project which also used Bokashi EM. The initial groundwork for building an understanding of food waste management with Bokashi was done during the pilot project in 2012. Thereafter, generating an understanding of the complexities of interactions in Enkanini was carried out by engaging with food waste collection participants and co-researchers in the Collective. This understanding facilitated the researcher, participants and co-researchers to work together to manage the food waste. These kinds of relationships are important for innovating local *in situ* options for organic waste recycling in Enkanini. The researcher began by first observing the food waste collections being run by co-researchers early on in the research process. This meant that she was able to first understand the everyday challenges residents of Enkanini faced regarding domestic waste management.

10. Practical Limitations

Due to the unpredictable nature of biological experiments, the composting process was not completed perfectly. However, the focus of this research was rather on the practical, social and community aspects and relationships that influence the effectiveness, acceptability, appeal and user-friendliness of food waste recycling (composting) in the informal settlement context.

Investigations for this research were done at the household level. Criticisms of this kind of approach include that ‘... so long as food security is a household-level problem and does not translate into a political problem, it does not attract policy attention’ (Maxwell, 1999:28). However, household level data can actually provide worthwhile contributions for informing political processes (especially for municipalities), which can make policy attention more meaningful. For this reason, the scale of this research is not seen to be a real limitation to the research. Limitations of the research are described in more detail in Chapter 6.

11. Research originality

In order to determine the originality of this research, a search was run on the NEXUS database, by looking for the following keywords:

- Food waste;
- Food production;
- Enkanini;
- Stellenbosch; and
- South Africa.

No results were received from this NEXUS search. These keywords were also checked in the NiPad database. No matches or related research were found. The searches were done using Boolean methods.

In terms of originality of the methodology and design in this study, the combination of Transdisciplinary and Participatory Action Research with the concept of *in situ* upgrading of biological and soil conditions and infrastructure in informal settlements is considered to be a relatively new and unusual approach to Informal Settlement Upgrading in general.

12. Conclusion

The research methodology used for this thesis is primarily based on the strengths of transdisciplinary and participatory action research and learning for sustainability. Research is informed by an awareness of characteristics of complex systems and the need to move away from contemporary linear and reductionist approaches to development problems, which can be interventionist and unsustainable in the long-term. By combining a number of methodologies, tools and methods, the research process was simultaneously creative and flexible. These characteristics were critical elements for ensuring that the research process was robust and appropriate to the informality, unpredictability and changeability of life in informal settlements in South Africa, and in Enkanini in particular. Despite this flexibility of the overall research approach, the researcher ensured that the research process was also systematic and rigorous enough for it to be documented within the timeframes required for completion of the thesis, as well as for its possible replication elsewhere.

Finally, it is necessary to be realistic and sensitive about the potential longer-term sustainability that a food waste collection project like this could have in an informal settlement context. This is because one needs to ensure that not only residents participating in the project are able to continue doing so, but that they are also able to play an active role in running the project itself (e.g. through setting up partnerships and enterprises connected to the food waste collections). It is especially critical to consider this continuity in terms of how a community can begin to take ownership and responsibility of such a project, as well as how the work can be reproduced

elsewhere. Such projects would need to create measurable benefits, incentives or employment, or demonstrate that they can generate profit. An example of both a meaningful and viable benefit and incentive was observed in the 2012 pilot project and this research. This was the reduction in vermin which participants had noticed and to which they responded by continuing to collect their food waste for the project. In addition, continued interest in this kind of food waste management work and research from the Stellenbosch Municipality and enterprise entrepreneurs to scale-up the project and support it in the future is encouraging.

Chapter 4: Results

“However beautiful the strategy, you should occasionally look at the results.”

Winston Churchill

1. Introduction

In this chapter, the findings of a range of quantitative and qualitative investigations into food waste collections, as well as soil, food waste and compost conditions in the Enkanini informal settlement and its surrounds are presented. These investigations have been done to determine the existing situation in the area concerning soil quality, nutrient availability, pathogen contamination and heavy metal concentrations. The results of these tests assist in determining the potential and safety of producing food (vegetables) or value-added products from or in Enkanini's soils, as well as that of recycling food waste to mimic nature's cyclic loops for resource management..

In addition, investigations were done into some of the social aspects of improved waste collection in Enkanini. The representation of these interactions and community participation culminated in a co-created, artistic public art piece in the form of a banner depicting a map of Enkanini, which was painted by the food waste collection participants. The thesis also explored the ecological and social potential or value of incremental *in situ* adaptations for organic waste management strategies in the context of this illegal and under-serviced informal settlement. Finally, these adaptations have been considered in terms of their ease of replication and their applicability more widely to other (similar or different) settlements nationally, regionally or internationally.

2. Waste in Broader Stellenbosch

In order to provide a context for the results of this research, it is necessary to set these results within the wider context of waste management practices in the greater Stellenbosch area as well as in Enkanini itself.

a. Stellenbosch solid waste

Stellenbosch Municipality (the municipality) released the latest version of their Integrated Development Plan (IDP) in March 2013. This document describes some aspects of the municipality's Integrated Waste Management Plan (IWMP), among other development strategies. The IWMP was developed in terms of South Africa's National Waste Management Strategy (NWMS) of 2010, and includes aspects of:

- Enforcement;
- Education;
- Awareness;
- Waste collection and treatment;
- Waste recycling, re-use and minimisation; and
- Waste disposal (Stellenbosch Municipality, 2013).

Some of the key issues which the municipality has identified in the IWMP as those that need attention include:

- Closing the existing Stellenbosch landfill (Devon Valley site);
- Investigating alternatives to the existing landfill, in order to comply with current legislation;
- Focussing on waste education and minimisation;
- Reducing amounts of waste going to the landfill;
- Managing information on waste, particularly data of waste at the landfill site, as well as the need for acquiring decent services at the landfill site to ensure its proper management (such as the installation of a weighbridge);
- Building capacity of waste management staff;
- Ensuring that adequate financial and human resources are assigned to the Waste management department;
- Reviewing of waste collection tariffs in order to make sure that costs are recovered properly;
- Being involved with industries to ensure responsible waste management and minimisation; and
- Ensuring alignment with Cape District Municipality plans (Stellenbosch Municipality, 2013).

b. Stellenbosch Landfill situation

It was proposed that a new landfill cell be built at the Devon Valley landfill site, in order to cope with the disposal pressure of the area in the short term (Resource Management Services, 2012). However, it was predicted that this cell would only last three years (Resource Management Services, 2012:1). Construction for this new cell began in 2012, and it was to be commissioned before the end of 2012 (Resource Management Services, 2012). The newly constructed cell is a

properly engineered sanitary landfill, unlike the original landfill cell. The municipality is also considering disposal alternatives such as having other drop-off areas, transfer stations and regional facilities (Stellenbosch Municipality, 2013).

In 2012, the construction of a public waste drop-off area at the Stellenbosch Landfill was approved (Resource Management Services, 2012). When constructed, the area will allow for recoverable waste to be separated from the non-recoverable parts of the waste stream. This recovered waste will then be recycled or disposed of appropriately (Resource Management Services, 2012). This waste recovery of separable materials will allow the landfill air space lifetime for the new cell to be maximised (Resource Management Services, 2012). Garden waste that is chipped at this drop-off or processing area will need to be taken to an approved composting facility (Resource Management Services, 2012).

c. Greening Stellenbosch

The municipality has indicated in its recent IDP that one of its goals is to be the 'greenest municipality' (Stellenbosch Municipality, 2013:100). However, the IDP does not clearly state what this will actually involve for the municipality. The IDP is vague, and the intended greening activities as well as their potential for positive impacts are unclear. The IDP identifies the critical need for building capacity amongst municipal officials, the private sector and in the community with respect to waste management best practices. Although the IDP is not entirely explicit in what measures will be taken to achieve this green goal, the need for having an integrated approach to development in the municipality is recognised (Stellenbosch Municipality, 2013).

d. Separation of recyclables at source in Stellenbosch

Tactics which are mentioned in the IDP for minimising waste in the municipality include the introduction of instruments such as subsidies for recycling, green taxes and financial incentives to generate less waste, such as the 'pay-as-you-throw' policy (Stellenbosch Municipality, 2013:83). A waste separation at source collection service was recently carried out by the municipality in higher income areas. Unfortunately, however, the recyclables which were collected have been stored, as the costs to transport them to recyclers are currently prohibitive for the municipality. The municipality has also identified the importance of involving communities, of creating public-private partnerships, and of considering alternative technologies for meeting the waste minimisation needs of the municipality (Stellenbosch Municipality, 2013).

3. Waste in Enkanini

Several waste characterisation studies were done by the Municipality in 2012 for a number of suburbs of different income levels around Stellenbosch. The study was carried out in June 2012

and included the Enkanini area. It indicated that a large portion (56%) of solid waste sampled from Enkanini consisted of organic matter (von der Heyde, 2012).

a. Municipal skips

There are currently seven open municipal waste collection skips (concrete collection areas) located around Enkanini, where residents are expected to bring their household rubbish. Waste management is often difficult for the municipality as roads around Enkanini are steep and narrow, and are often slippery and difficult to drive on, especially after rain. The black rubbish bags sometimes provided by the municipality to households in Enkanini for waste are not always used for waste collection. This is because they are useful to residents for other (more urgent or practical) purposes. Residents use other packets, containers and methods for collecting, storing and carrying their waste to the skips.

b. Pilot food waste project of 2012

A food waste management pilot project was carried out at the end of 2012 for nine weeks, and was sponsored by the Stellenbosch Municipality and ProBiokashi (Pvt) Ltd. One of the students in the Transitions Collective, Vanessa von der Heyde, was in charge of co-ordination and practical running of the project, as part of an internship with the Stellenbosch Municipality. The project involved the use of wheat bran inoculated with Effective Microorganisms (EM), also known as Bokashi, as the primary food waste management technology. T

c. Continued pilot project – food waste collections in 2013

The case study for this thesis was based on the continuation of the 2012 food waste pilot project. The project was run for almost the whole year using the researcher's funding from the FSI. Data for this case study was captured between March to July 2013 (although the project continued until December 2013).

4. Results of 2013 collections

a. Participation in 2013 collections

Overall, it was estimated that 56 households participated in food waste collections in the 20 week period between March and July 2013 when data for this case study was collected. The original number of households in the pilot project in 2012 was 100. This estimation for 2013 participation was calculated by combining attendance lists collated by Vanessa von der Heyde during the pilot project in 2012 with weekly attendance lists compiled by the researcher and co-researchers in 2013. The difference represents about a 40 to 50% reduction in participation since 2012. In the 2012 pilot project, an indirect but substantial incentive cited by participants for collecting and separating their food waste was a reduction in vermin (rats) in or around their houses (von der Heyde, 2012). It appears that this incentive may be one of the main reasons that the remaining

participants continued to collect their food waste in this extended pilot project in 2013. Reasons for the reduced number of participants are unclear and are discussed in the limitations of the project in Chapter 6.

In the 2013 project, when respondents were questioned about how they had heard about the Bokashi food waste collection project, most of them (82%) said that they had heard about it from calls on a loudhailer in the settlement. These calls were done by co-researchers, to connect with any people interested in participating in such a project. This approach is interesting from research, activism, community work and project management perspectives. The success of using a loudhailer indicates the power and extent of localised influences which co-researchers have in communities, as well as the speed at which people can spontaneously be organised and mobilised to participate in their community. The effectiveness of this loudhailer work also indicates the degree of reliance which researchers (such as those in the Collective) have on relationships with co-researchers and, in turn, on the relationships, statuses and roles which co-researchers have in their community.

b. Demographics of collection participants and frequency of drop-offs

The majority (82%) of interview respondents were women. Most participants (90%) were between the ages of 23 and 40. The most common household size for participants was 3 household members. Of the participants interviewed, most of them (82%) brought their food waste to collections every week.

c. Participant comments on food waste collections

Most respondents (90%) said that they felt that there were no disadvantages to collecting their food waste separately for this project. When asked about their reasons for participating in the Bokashi project, respondents provided a variety of answers. Most of these answers related to general cleanliness and the subsequent avoidance or reduction of vermin near their houses. The frequencies of responses were as follows:

- To avoid or get rid of rats (33%);
- To keep the house clean (17%);
- To have no smells of the rubbish (17%);
- To have a lighter rubbish bag (17%);
- To be neat (8%); and
- To meet new people (8%).

d. Participant knowledge of agricultural practices or food gardening

In order to determine participant attitudes and the potential of carrying out UA in a place such as Enkanini, participants were asked a few questions about their knowledge of or exposure to food gardening or agricultural activities. This was done in a subtle way in the survey, however the intention of these questions was to provide an empirical link between the focus in this thesis of the connections between UA, education and household waste re-use options. The majority (73%) of respondents said that they had not been exposed at all to any opportunities for learning about agriculture. However, in an encouragingly strong response to this, many respondents (91%) expressed an interest in learning about food gardening or agriculture in the future.

Respondents were asked about whether they knew what compost was, and 55% of them indicated that they were not aware of what it was. Strangely, perhaps, despite not knowing what compost was, when asked what should be done with food waste, many (82%) suggested that it should be used to make compost. However, the responses of these participants may have been biased because on the day of many interviews, the composting drums were outside and composting activities were being carried out. With regard to the process of actually making compost, 64% of respondents indicated that they felt that residents of Enkanini should be responsible for making compost from their food waste.

When respondents were asked whether they knew anyone in Enkanini who had raw materials for possible use in making compost, responses were divided fairly broadly. Those not knowing anyone with materials made up 36% of responses, while 18% were unsure, 18% said that they did know someone with materials, 9% preferred not to answer and for the remaining 9% of responses, there was no response captured.

e. Participant attitudes to community composting and gardening

Participants were asked how they felt about the potential for community composting using food waste. When questioned about the destination of the compost, a high number (82%) of respondents agreed that compost made in Enkanini could or should be sold outside the settlement. In the light of the co-production and design priorities for options for incremental food waste management in Enkanini, this outcome should be considered as a critical response for the future of the project. This is because it indicates the potential willingness of participants to explore an income stream from value-adding activities such as composting.

5. Space requirements and logistics for 2013 collections

a. Food waste storage and challenges

In the initial pilot project of 2012, only six large brown 220 litre drums for storage of food waste were available. These drums had plastic lids and screw-on seals, which were closed when drums

were full, or before they were moved to where food waste was used. Due to the small number of these drums, the food waste collected was used almost every week (during the 2012 project) for composting in various locations in Enkanini and at a school in the neighbouring area of Kayamandi.

Figure 11 shows one of these large brown 220 litre drums with the plastic ring seal on the lid (black).



Figure 11: Example of the large brown 220 litre drums used during 2012 and 2013 collections (Source: Ivan Volschenk, 2014).

During the 2013 project, manoeuvring and loading and unloading the full 220 litre drums from collection trucks became increasingly difficult and time-consuming (especially because they did not have handles). The pressure and weight of the contents of the drums when rolling them around lead to two of them being split and damaged. It was decided that the large 220 litre drums were inappropriate for use in the food waste collections.

In the course of the 2013 project collections, five 120 litre drums were bought in order to cope with the extended storage needs for food waste and to streamline the collection system with the waste collectors, Agriprotein and Cobus Smit, from Paarl Nursery. These smaller capacity drums were much easier to move and roll around, especially when food waste needed to be transported. They had plastic lids and a flexible metal seal which was snapped closed once drums were full. Empty

and full drums were usually swapped on the same day i.e. collectors did not need to make a second trip to return the empty drums. This assisted in reducing the time and transport costs and logistics for the researcher, as well as for Agriprotein and Paarl Nursery. Other smaller and more mobile drums were temporarily borrowed from Agriprotein for food waste storage purposes when this became necessary.

Figure 12 shows examples of the smaller blue 120 litre drums with their metal folding ring seals and black lids.



Figure 12: Example of smaller blue 120 litre drums used in 2012 and 2013 collections (Source: Ivan Volschenk, 2014).

b. Distance from participants' homes to food waste drop-off site in 2013

It is necessary to consider the real and practical challenges which food waste collection participants faced every week in order to drop off their household's carefully collected and separated food waste. Difficulties such as carrying heavy buckets and walking on slippery or steep paths for several hundred metres or even a few kilometres may seem trivial. However, these kinds of practical challenges are considered to be significant factors which could affect participants' willingness to continue participating in waste collection activities. It was therefore surprising to note that a few of the participants (9%) came from Zones G, H and I, which are downhill and a considerable distance from the drop-off shack (which is located in Zone E). Many participants (39%) came from Zone F (uphill from the drop-off shack), and more than one quarter (27%) came from Zone E, where the drop-off shack was located (see Figure 4 for a map of zones in the area).

6. Creative mapping and painting workshop for food waste collection participants

A meeting was held before the first painting workshop, where the researcher, Susan and Gwendolyn discussed their different ideas about what and how painting activities could be included in the food waste collection project. An agreement was reached on what they felt would best represent all their research interests, as well as be enjoyable for the participants and themselves. Susan decided to paint a basic outline map of Enkanini on a canvas banner, showing the demarcations of the different zones of Enkanini. The researcher felt that a natural element was needed as a representation of the biological aspects of the collections, and so the symbol of a tree was chosen. Together, the three researchers agreed that participants would be asked to paint a tree symbol. However, it was decided that this would be the only requirement of participants - they were allowed to interpret their image of a tree however they wished. This was interesting for Gwendolyn, whose interest was in the participants' individual abilities for making unique designs and marks. Participants were asked to paint this tree symbol in the area (zone) on the map in which they live in Enkanini. They were then encouraged to sign their name next to their tree, to make sure they recognised their personal contribution both physically on the map and practically in terms of their own waste collections. Given the spontaneity of the expectation of participants to paint trees, it emerged that some residents actually decided they wanted to paint something else (such as a human figure). They were obviously allowed to do this, in the spirit of the co-produced banner.

After participants had finished painting, photographs were taken of them, which were later printed. These photographs were subsequently given as gifts to the participants as a gesture of appreciation for their participation and continued efforts in the collections. They seemed to be delighted with the photographs. It is hoped that the completed banner will be hung up in the Collective's new Research Centre, to form part of a display of work being done by residents and researchers in Enkanini. Participants will be able to see the banner whenever the Research Centre is open. Future users of the Research Centre meeting spaces will also be able to see the banner and learn about the project in this way. Together with co-researchers, it was decided that the banner (and project for 2013) be given a name in Xhosa. This name was *Singapumelela*, which means "we can achieve". The name was painted on the banner by Susan when it was completed.

Figure 13 provides an illustration of some of the participants painting the banner.



Figure 13: Bokashi food waste participants making their marks (tree symbols) on the project banner (Source: Susan Immelman, 2013).

Figure 14 indicates the finished banner (note the three circular arrows near the centre of the photo). These represent the recycling of food waste, the symbol for the Bokashi food waste drop-off centre. The use of this recycling symbol was proposed by Gwendolyn as one of her ideas for investigation of recognition of symbols and how they can be used to communicate information.



Figure 14: Singapumelela Bokashi food waste collection banner – 2013 (Source: Susan Immelman, 2013).

7. Composting of Bokashi food waste in Enkanini

a. Composition of compost trials

The composition of the Bokashi-treated food waste compost made in the green rotating drums is illustrated in Table 1. This indicates the percentages of different ingredients by weight and volume.

Table 2 shows the same information for the control compost (which did not contain Bokashi-treated food waste), which was also made in one of the green rotating drums.

Table 1: Percentage composition by weight and volume – Bokashi compost (Source: Author, 2013)

MATERIAL	PERCENTAGE WEIGHT COMPONENT	PERCENTAGE VOLUME COMPONENT	TOTAL NUMBER OF BUCKETS OF COMPONENT	TOTAL WEIGHT OF CONTENTS (KG)
Grass and weeds	2	9	1	155
Research Centre soil (loam)	19	9	1	
Alien chippings	7	27	3	
Cow manure	12	14	1.5	
Spier compost	2	9	1	
Bokashi food waste (one month old)	50	27	3	
Water	8	5	0.5	

Table 2: Percentage composition by weight and volume – control compost (Source: Author, 2013)

MATERIAL	PERCENTAGE WEIGHT COMPONENT	PERCENTAGE VOLUME COMPONENT	TOTAL NUMBER OF BUCKETS OF COMPONENT	TOTAL WEIGHT OF CONTENTS (KG)
Grass and weeds	4	12	1	92.5
Research Centre soil (loam)	32	12	1	
Alien chippings	11	35	3	
Cow manure	22	18	1.5	
Spier compost	18	18	1.5	
Water	13	6	0.5	

b. Results of compost tests

Compost samples were tested for nutrients, moisture content, acidity, heavy metals and bacterial activity and contamination. All compost samples had a pH within the recommended range between 6 – 7,5. Almost all samples had very low resistance (conductivity) levels, with figures of less than 400 Ohms. Many of the samples had high manganese concentrations. The compost made in the crate at the Research Centre using food waste from the initial pilot project in 2012 had the highest iron content of all soil and compost samples tested. These very high levels are not expected to negatively affect vegetable growth.

The vermicompost tested from Eric's farm had slightly elevated mercury and antimony levels, according to acceptable concentrations in soils. In addition, the Spier compost tested had mercury levels that exceeded acceptable limits for soils. However, when used on the farms, both of these kinds of compost are thoroughly mixed into the soil, meaning that the concentrations of these contaminants are more than likely reduced. Although this was not tested in practice in this study, it was assumed that these levels would be within acceptable limits once mixed with soil. As mentioned, the Spier compost was used as one of the ingredients for making the compost in Enkanini in the rotating drums. The compost made from Bokashi-treated food waste as well as the control compost for this experiment both had heavy metal concentrations that were within acceptable limits for soils. This indicated that the heavy metal levels of the Spier compost were, in fact diluted suitably in this case study composting process. In terms of compost quality, comparing

the compost experiments for this case study (the Bokashi-treated and control compost), it was found that the control compost had a much higher concentration of bacteria per ml. In addition, the Bokashi-treated compost had a lower pH, higher moisture content, higher nitrogen and phosphorous levels, as well as higher iron, zinc and carbon concentrations. All of these characteristics and elements are considered to be important for good plant growth.

8. Soil quality testing

In general, soil samples tested very high for phosphorous and potassium. However, these levels were not considered to be problematic for cultivation of vegetables. Most samples had very low concentrations of copper and boron, which are essential minerals for plant growth. The manganese levels in beds and soils of the iShack and Polla Park were higher than the recommended ideal levels for cultivation. The highest concentrations of iron were also found in the soil adjacent to the iShack, as well as in the vegetable beds at Polla Park.

None of the soils tested require lime to adjust their acidity levels for vegetable cultivation. However, it was found that the Polla Park and iShack vegetable bed soils (in Enkanini) were a bit too acidic for optimal vegetable growth. Most of the soil samples were considered to be loamy (a good mixture of sand, clay and silt), which is a good soil type for vegetable cultivation. The only site which had very high clay levels which can make cultivation difficult was the open patch of soil at the Bokashi shack. All heavy metal levels in all soils were found to be within acceptable limits.

Tests for bacterial activity came back positive for *Escherichia coli* (*E. coli*) in all soil samples. However, none of the soil samples tested positive for *Salmonella*. Levels of *E. coli* were highest in the Polla Park bed, at 1178 *E. coli*/g.

Table 3 indicates the overall base saturation or general fertility levels of soils tested. This is referred to as the T-value, which represents the overall availability of micronutrients and surfaces for ion exchange on soil particles. Fertility levels were highest in the Legacy Centre vegetable bed, which has been repeatedly fertilised with Bokashi compost made there from food waste from the Stellenbosch area for several years.

Table 3: General fertility levels of soil samples (Source: Author, 2013)

Sample site	T-Value (cmol/kg)
Legacy Bed	19.4
Legacy Soil	14.03
Polla Park Bed	11.81
Polla Park Soil	6.76
Bokashi Shack Soil	11.78
Ishack Bed	9.5
Ishack Soil	7.71
Centre Soil	9.33

9. Food waste quality and safety testing

a. Samples used

Four samples of solid and liquid food waste from the Bokashi food waste collections in Enkanini were taken in May and June 2013 (two solid food waste samples and two liquid food waste samples). The first solid food waste sample was approximately one month old (called 'new' food waste). This solid food waste was not completely fermented, and had not been maintained in strictly anaerobic conditions. Later, a second solid food waste sample was taken from the same container, when the food waste was about two months old (called 'old' food waste). Again, it had not been kept in anaerobic conditions. This is because closing containers and allowing them to ferment means they begin to produce carbon dioxide, and if left for some time like this, there is the possibility that they drums will burst or pop their seals. This could be a real hazard in the context of compact living spaces in Enkanini and the potential for nuisance and attraction of vermin. Both food waste samples were tested for nutrients, bacteria and heavy metals. The two liquid food waste samples were taken in June 2013. These were tested for nutrient content, heavy metals, bacteria and microbiological activity.

b. Results of food waste tests

The 'old' food waste sample had a moisture content of 75%, while the 'new' food waste had a lower moisture content at 68%. This is probably due to the fact that as food waste sits for longer, it begins to ferment more, and liquid from the food waste is produced in this process. The moisture

content of the 'new' food waste may have been much higher if the liquid draining from food waste when collected by participants had not been poured off at collection days. The liquid that drained from food waste was tested on one occasion, when the liquid was about two weeks old. In contrast to solid food waste samples, the liquid waste had very low concentrations of all nutrients.

The solid and liquid food waste contained some traces of heavy metals, although all were very low and within acceptable limits. Both the 'old' and 'new' solid food waste samples had very high total bacterial activity, with counts of 1,59 million bacteria and 2,96 million bacteria per gram of waste respectively. Bacteria were not identified in this research. However, the figures suggest that bacterial concentrations can still be reduced by storing Bokashi-treated food waste aerobically over time.

10. Black Soldier Fly (BSF) larvae food waste residue tests

Nutrient, bacteria and heavy metal tests were conducted on two different samples of food waste residue that was left after processing (consumption) of some mixed food waste by BSF larvae. These residue samples were provided by Agriprotein. The residue that remains after larvae have eaten the waste consists mostly of their faeces and inedible food pieces (such as hard vegetable peels and skins). However, this waste residue is still useful as an ingredient for composting. Thus the efficiency of larvae food waste processing is relatively high.

The residue samples provided for testing from Agriprotein included:

- A sifted sample of fine particles of residue that was from mixed food waste processed in the period of January – May 2013; and
- A mixed sample of food waste residue (containing larger pieces of food waste such as hard husks and fine particles of residue) – from May 2013.

a. Residue nutrient levels

Both samples of residue from the BSF larvae processing contained very high levels of copper concentrations – with levels greater than 100mg/kg. These levels are much higher than the recommended levels for soils, which are about 5 – 25 mg/kg (see Appendix 5). Most of the food waste which larvae had processed which resulted in the generation of these residues comes from some of the Stellenbosch University residence cafeterias. Most of the water used to cook and wash food in these locations is piped through traditional copper piping. This copper could therefore be concentrated into the food waste in these ways (Banks, I., personal communication, 10 September 2013).

Both residue samples also had very high levels of manganese, with the mixed processed food waste residue containing about 84mg/kg and the sifted residue about 162mg/kg. A possible

explanation for this could be that the source of this manganese is actually the Bokashi EM used to treat the food waste. This is because Bokashi is primarily made from wheat bran and the EM mixture. Crude wheat bran generally has high manganese levels, which can be up to about 11,5mg/100g (Health Alicious Ness Website, 2013). This translates to concentrations of 115g/kg. The samples also had high percentages of carbon, with the mixed processed food waste residue containing 32% carbon, and the sifted residue containing 37% carbon.

b. Residue bacteria concentrations and heavy metal levels

The residue samples contained very high levels of bacterial activity, as well as high levels of *E. coli* concentrations. Both of these concentrations were >24196 *E. coli* per 100ml. However, both samples tested negative for *Salmonella*, and as such, it is not expected that the *E. coli* strains in the residues were harmful. The sifted residue contained very high bacterial diversity and activity, with levels of >3 000 000 bacteria/ml. All heavy metals were within acceptable limits for both residue samples tested.

11. Existing food production in Enkanini

Through observations of residents' activities in Enkanini, discussions with co-researchers and general area visits, it appears that most vegetables being grown in Enkanini are being used directly by residents growing them for their own household use. The most commonly grown vegetables are spinach, onions and cabbages, which are used in some traditional dishes which the residents prepare for their families.

Due to time constraints, the extent of food gardening being practised in Enkanini was not fully investigated in this research. Only one location where vegetables are being grown by an independent resident was investigated, namely the area called Polla Park in the soil sample testing. An informal, brief and open interview was conducted with the resident in charge of this garden, called "George".

Some of the questions which the researcher asked "George" included:

- Do you sell any of your produce?
- Do you use any fertilisers or pesticides in the garden?
- Do you have any problems with theft or pests?
- Where do you get your water for the garden?
- Who works in the garden?
- Where do you get the seedlings for your garden?
- For how long have you had your garden?

The vegetables in the Polla Park garden appeared to be very healthy and lush, were planted in neat rows, and were carefully fenced and protected (with a hand painted sign warning trespassers not to enter the garden). The range of vegetables planted included:

- Spinach;
- Beetroot;
- Onions;
- Maize; and
- Cabbage.

“George” said he obtains vegetable seedlings from the Stellenbosch Municipality, where was employed. With the help of a neighbour, he had informally adjusted the municipal water connection so that it was more accessible for his garden. This had the added indirect benefit of increasing ease of access to water for his neighbours as well. This saves them a longer trip to the municipal communal toilet block taps. He said his brother assisted him with labour in the garden, and that he did not use any fertilisers or pesticides. “George” said that in the future he would like to be able to produce his own seedlings. He also mentioned that one of his greatest needs was a supply of compost to feed his vegetable beds.

In terms of the destination of the outputs of his garden, “George” said that he shared the produce with his neighbours that live close to his house (opposite the garden). He said that he shared the produce with these people if they asked him for permission to do so, and that he did not charge them for the vegetables. He said he had no problems with theft of his produce.

The researcher noticed some two litre bottles of water haphazardly strewn about the Polla Park garden, and found this curious. Upon consulting “George” about them, he explained that the bottles prevented dogs from entering the garden and trampling, digging up or destroying the vegetables. Although this may not have been formally proven through research, and appeared strange at first, it seemed to be an ingenious, low-technology and cheap method of reducing damage to vegetables, especially in the context of an informal settlement environment.

12. Ecological, health and economic costs and benefits of food waste management strategies for Enkanini

a. Completing the food waste loop using BSF larvae

Much of the food waste collected in Enkanini was sent to an experimental agricultural enterprise called Agriprotein outside Stellenbosch, in Elsenberg. The food waste was fed to Black Soldier Fly (BSF) larvae (*Hermetia illucens*) which are used to produce agricultural feed for chickens and fish. The percentage reduction of food waste that the BSF larvae are capable of achieving when feeding

on food waste is a 50% to 75% reduction (by weight) of the food waste over a period of 20 days (Watson, P., personal communication, 18 July 2013). Currently, BSF larvae at Agriprotein are fed food waste from a number of sources (including from Stellenbosch University residence cafeterias), and most, but not all, is treated with Bokashi. In addition to this waste weight reduction, there is the further benefit that the residue that is left after larvae have processed food waste can be composted (Watson, P., personal communication, 18 July 2013).

b. Diversion from landfill

One of the main motivations from the Stellenbosch Municipality's perspective for encouraging the initial pilot project of 2012 was the diversion of organic waste from the town's landfill. Diversion from landfill also represents a general saving in municipal transport costs, as well as an improvement of health benefits and pest management costs in the Enkanini community.

The total weight of food waste collected in the extended project over 20 weeks (March – July 2013) by the 56 households involved was estimated to be 5,851 tonnes. This translated to a quantity of about 1,17 tonnes per month. The total weight collected was calculated using the number of drums of waste collected multiplied by their average weight (calculated using a large scale at Agriprotein's facilities). This quantity of waste represents an average amount of about 5,2kg of food waste per household per week. However, by inspecting the data at a more detailed level (analysing data from May to July and weighing collection buckets on a weekly basis over a shorter time period), it was found that households participating in the project generated a weekly average of 9,6kg of food waste. Laboratory testing by BEMLAB revealed that the food waste had a density of about 980kg/m³. Therefore the approximate landfill space saved through collecting all the waste was 5,97m³. On a monthly basis, this represents a saving of about 1,09m³ of landfill space.

Based on a household production of 5,2kg of food waste per week (a conservative figure), if this project were scaled up to serve the whole of Enkanini, an area consisting of about 2400 households, the following results might be achieved:

- The collection of approximately 50,2 tonnes of food waste per month; and
- The saving of 51,2m³ of landfill space per month.

The price per tonne of the disposal of general waste at the landfill has increased from R125,49 per tonne in 2012 to R136,16 per tonne in 2013 (de Wit, 2013:7). This rate has now recently been increased further to R390,20 per tonne and R195,10 per half tonne (Haider, S., personal communication, 2013). This means that the costs that could be saved by diverting 50,2 tonnes of food waste per month from the landfill might amount to R19 568 per month for the municipality.

Disposal rates of waste at the Stellenbosch landfill were about 52 000m³ for the first seven months of 2012 (de Wit, 2013:3). This translates to about 7428m³ per month. According to recent estimates, it is expected that the new landfill cell at the Devon Valley landfill site in Stellenbosch will reach its approved height limit in just 20 months if disposal continues at current rates (de Wit, 2013:14). In the waste characterisation studies that were conducted in 2012 and early 2013 for the Stellenbosch Municipality for a range of areas, it was found that organic solid waste made up the greatest proportion of municipal solid waste by weight – at a percentage of 37% (de Wit, 2013:7). De Wit's feasibility study for waste management in the Stellenbosch Municipality (2013) recommended that major interventions to reduce the amount of waste going to landfill on a large scale are needed, and that they need to be implemented urgently. Thus, practical alternatives for dealing with organic waste, such as those investigated in this research, are vital and urgently need to be considered by decision- and policy- makers as real alternatives for minimising amounts of waste sent to the landfill in Stellenbosch. These alternatives may be applicable in other South African cities, and further afield as well.

c. Food production potential of Bokashi composting

Composting of Bokashi-treated food waste is currently being done at the Knorhoek Wine farm vegetable garden, where some compost samples were taken for this study. The food waste (kitchen waste) for their composting comes from their restaurant and guesthouse. The following are estimations of the productivity and the practical requirements for this kind of composting to be done on a medium scale.

About 200g of Bokashi EM mixture (on wheat bran) is needed for sprinkling on layers of food waste in a 20 litre bucket (van Niekerk, I., personal communication, 2 September 2013). This works out to about 1kg of Bokashi EM per 100 litre drum (van Niekerk, I., personal communication, 2 September 2013). Next, two 100 litre drums of food waste (containing about 2kg of Bokashi EM) are used for composting in a vegetable bed that is approximately 5m².

An example of the amounts and kinds of vegetables that can be grown from two 100 litre drums of food waste and in a vegetable bed of 5m² are as follows:

- 50 lettuces; or
- 10 tomato plants; or
- 20 spinach plants (van Niekerk, I., personal communication, 2 September 2013).

13. Options for decentralised food waste recycling

a. Agricultural feed production (BSF larvae)

During some discussions the researcher had with one of the co-researchers during the research, it was suggested that Agriprotein consider setting up training workshops for residents of Enkanini to

work with the food waste and BSF larvae in Enkanini itself. The idea behind this is that residents could acquire skills and at the same time be exposed to the possibility of job opportunities linked to larvae production and sale.

Although it would logistically make sense to have these larvae production workshops located in Enkanini itself, the potential implications of having flies in a densely populated informal residential area would need to be taken into consideration. Also, cultivating the fly larvae is a very intricate, delicate, detailed and scientifically precise process, requiring the constant input of highly skilled and trained professionals.

If agricultural feed from the larvae were produced locally in Enkanini (or as close to Enkanini as possible given the space implications of this), it might encourage local entrepreneurial and other skills development, as well as job opportunities for residents of Enkanini. The economic benefits of producing BSF larvae can be interpreted as follows - Agriprotein sells live BSF larvae to an agrifeed supplier, whereafter they can be sold to chicken farms which rely on feed coming from 'sustainable sources' (Watson, P., personal communication, 30 August 2013). The live larvae sell at about R400/kg, and their dry and milled price is still to be determined (Watson, P., personal communication, 30 August 2013).

b. Container Composting

The quantity of food waste generated by participants in collections in 2013 was greater than the composting drums were able to manage. However, if the drums had been rotated more frequently and if they had been located outside to warm in the sun every day (or at least more than once, as was the case in this research), the processing time of the compost could probably have been much shorter. It was not possible to compost all of the food waste generated in the collections given the storage space limitations in the collection drop-off site, as well as the numbers of sealed drums for food collection.

c. Anaerobic biodigestion of food waste

Food waste collection participants could place their waste in communal and locally accessible biodigestors. The effluent (wastewater) from the biodigestors could be used by participants in their own vegetable gardens (if they have these), or in a community garden if located near the biodigestors. The shared use of biogas would need to be carefully arranged and designed so that food waste collection participants are organised according to where they live. Biodigestors could be built using local, simple and low-technology materials by residents themselves, following, learning from and guided by skilled engineers and supervisors. By assembling or building the simple digestors themselves using local materials, the implications of any loan re-payment arrangements for the installation of such infrastructure could be more affordable and attractive to

residents. A biodigester was installed at the Research Centre in Enkanini in 2013, a short distance from the Bokashi food waste collection shack used in 2013. The biodigester is linked to four toilets used by 12 households, which are part of research into options for incrementally improving sanitation services which other researchers in the Collective are conducting. Some preliminary tests on use of Bokashi-treated food waste in biogas digestors (Chili & Norman, 2012) suggest that it can be used in biodigestors and does not reduce the efficiency of the digestors in producing methane.

If participants begin to collect food waste and treat it with Bokashi EM and add this to the biodigester, they would need to be advised that certain food waste components cannot be collected – such as onions, citrus fruit and bones. This is because highly acidic food stuffs can affect the overall pH balance of the liquid waste in the biodigester, and this affects the ability of microbes to decompose wastes and produce biogas. In addition, the accumulation of bones in the bottom of the biodigester could mean that the digester could eventually become blocked up and therefore inefficient. Also, the bones may contribute to modifying the pH of the digester waste (due to their calcium carbonate content), and could therefore negatively affect the ability and efficiency of microbes to act on waste. An employee would need to be appointed and trained in order to regularly check and monitor all waste collected by participants before disposal in the biodigester, in order to ensure that no inappropriate food wastes enter the biodigester.

14. Discussion

a. Food waste collections

The reasons for the reduction in participant numbers between the 2012 and 2013 waste collection projects are not clear. They are undoubtedly numerous, and linked in a number of complex ways. One of these reasons could be that some collection buckets were used and destroyed in a fire which swept through and shocked Enkanini in the first part of 2013. In addition, the first pilot project had incentives (or rewards) for participants, namely two celebratory barbecue parties. The 2013 project did not involve any such activities, and relied entirely on the willingness of existing participants to continue collecting their waste and dropping it off at the collection centre. The subject of incentives and rewards for residents participating in such projects is a sensitive but important aspect of such projects. These aspects were not explored in detail in this research, and interpreting their nature was limited in this study.

At the end of the research period, two of the collection participants requested access to the Bokashi and control compost made in green drums for use their own gardens near the drop-off centre. In addition, a third participant spontaneously created her own garden outside the collection shack. It was suggested that she use some of the compost generated in the research, which she accepted. In line with compost testing results, all participants using this compost were advised that

they needed to cook their vegetables or wash them well before consuming them. This exchange may be seen as a small kind of reward to participants, however the nature of these interactions was not investigated in detail. Further interviews with these participants is necessary to understand the motives for their behaviour.

There were some new participants in the 2013 collection project. Also, the number of co-researchers employed on the Collective team increased between 2012 and 2013. Most of these new co-researchers began to collect their food waste due to their involvement in the work associated with food waste collections. Most of these new co-researchers became involved because they were neighbours or friends of previously existing co-researchers. This, again, indicates the significant role of social links and relationships between co-researchers and residents.

The figure of 5,2kg of food waste generated per household per week is considered to be a conservative estimate of food waste generation characteristics of households in Enkanini. The detailed analysis of food waste generation indicated that a higher figure of 9,6kg per household per week was generated, and this was considered to be more representative of the real waste generation characteristics of the settlement. It is recommended that any future estimations or project work use this higher figure in calculations. Alternatively, the average of these two figures could be used, which is the generation of about 7,4kg of food waste per household per week.

b. Soil, compost and food waste safety

The sources of *E. coli* found in samples are likely to be numerous. One such source could be due to the challenging sanitation levels in Enkanini associated with limited access to municipal toilets, which means that open defecation sometimes occurs. In cases where *E. coli* levels were found to be high, it was recommended that any vegetables grown in these soils or compost be cooked first or washed in chlorine water (Raath, Dr P., personal communication, 4 July 2013). The actual strains of *E. coli* found in samples were not determined in this research. An assumption was made that the *E. coli* found in samples (compost, soil and food waste) were benign. This is because harmful strains of *E. coli* are usually found to co-exist with *Salmonella* (van der Merwe, R., personal communication, 29 May 2013). However, it is important to note that the presence of *E. coli* is almost always representative of faecal contamination (Raath, Dr P., personal communication, 4 July 2013).

c. Composting or recycling options

It was assumed that much more compost could have been generated and processed if more space and container composting and storage drums had been available during the research. However, larger activities such as this would also require that a suitable area be secured in an outside area

for warming of the compost and eventually exposing it to the elements and soil microbes and other organisms essential for decomposing it. In addition, the proportions of food waste in relation to other composting ingredients could be increased in order to speed up the amounts of food waste that can be composted in the area. Nevertheless, it is envisaged that the composting of food waste alone (whether in containers or in the ground) will still not fully utilise the food waste resources generated in the settlement in an ongoing operation.

The location and timing of the installation of a biodigester in Enkanini at the Research Centre represents a perfect opportunity for testing methane generation and for managing the Bokashi food waste *in situ*. It could also allow for the symbiotic co-creation of synergies with other research initiatives being carried out in Enkanini through collaborative interactions between researchers. The effluent leaving the digester could (theoretically) be used as a liquid fertiliser on food gardens in the settlement. Therefore, several opportunities exist for managing Enkanini's food waste biologically and in a more cyclic way.

d. Existing food production

The researcher conducted a single interview with one Enkanini resident growing his own vegetables on a large patch near his home. She also observed some small backyard gardens whilst working in Enkanini. These very basic and preliminary insights suggest that there are very few home food gardens in the settlement. More in-depth interviews and extended observations are needed to determine the actual details and characteristics of food production in Enkanini more accurately. Extensive surveys and observations of all residents growing produce need to be conducted, as well as investigations into locations (and conditions) of unused sites which have potential for use as community or group gardens, in order to determine the real food production potential of Enkanini.

e. Social cohesion, participation and education

The painting workshop was a manifestation of the social networks and relationships which interactions during this research project fostered, which emerged or were encountered. These characteristics included cohesion, a sense of community, collective activities as well as contribution to the participants' sense of achievement. Once the banner was completed, a great variety of unique, imaginative, creative and skilful designs of different tree symbols could be seen on the banner, which were painted by participants. This variety was curious and inspiring, both for the researchers and the participants. Participants' work allowed a personalised, co-created map to be generated, which serves as a useful artistic and geographical illustration (and educational artefact) of the spatial distribution of participants in the extended food waste collection project. The workshop enabled an interesting transdisciplinary mix between art, design, geography, sociology

and biological science to be represented and created in a unique way by all those involved in the project.

15. Synthesis

The results illustrated in this chapter highlight the often invisible and fragile connections that exist between human and biological elements of the Enkanini community, and other communities as well. The case study also helps researchers to understand the dependence of these elements on a healthy and supporting ecology and environment, and the interdependence of these human and biological elements upon each other. The tool used in this research to make these connections more visible, both to those involved, as well as to 'outsiders' was that of 'hard science'. This refers to the conventional biological testing of soil, compost and food waste which were the biological elements in the research. However, in this thesis, hard science was used in a unconventional way, and, arguably, in an unlikely location. This is because it was located in a social context and because PAR was used as well. In this way, the research contributed scientifically to the body of research on informal settlements which typically has a strongly social bias.

The social and demographic characteristics and behavioural observations of Enkanini residents participating in food waste collections have been summarised in this chapter. A social learning strategy was used in order to determine the social aspects contributing to residents' participation in the food waste collection project. This kind of social learning was also done to work out whether the project has potential for expansion into similar and other areas in the future. With respect to participants' behaviour, it was found that most of them collect their food waste regularly and bring it to the collection centre weekly or fortnightly. In terms of participant demographics, the majority were women, and were between the ages of 23 and 40. This indicated an interesting gender and age dimension of participating households in Enkanini, which should be considered for future expansion or replication of the project. Characteristics of participants were seen to indicate the kinds of residents who are actually willing to participate in something new or interesting for their community. Also, the demographics characteristics (i.e. the prevalence of women participants, and of a dominant age group of 23-40 years) form a practical illustration and provide insight into how domestic duties and roles are experienced and lived on a daily basis in the social and practical context of this settlement.

The SL connection between food production and this food waste project was explored and subsequently illustrated through participants' responses in questionnaires. These responses indicated that most participants were interested in learning about agricultural activities which could be connected to composting activities using the food waste they generated and collected.

16. Conclusion

In this chapter, the social, ecological and biological characteristics of a food waste collection project that was run in the Enkanini informal settlement near Stellenbosch in 2013 were described. The spatial relationships between the different soil, compost and food waste sample sites as well as the sources and final destinations of food waste collected in the project were described and illustrated using maps.

The results of laboratory tests run on soil, compost and food waste samples sourced from in and around the study area were presented. The qualities and conditions of uncultivated soil, selected vegetable garden soil and various kinds of compost (including some made with and without Bokashi EM-treated food waste) were compared. Results indicated that in general, soils conditioned with Bokashi-treated food waste over long periods had higher nutrient availability and higher overall fertility for vegetable production. Pathogen tests were done on samples, and it was found that some had high amounts of *E. coli* bacteria (this was inconclusive as the strains were not determined). However, these results were not considered to be a significant barrier to continuation of the food waste collections, and minimal precautions on consumption of produce from these soils were recommended. Furthermore, *Salmonella* was not present in any of the soil, compost or food waste samples tested for this research.

In order to determine the characteristics of food production already occurring in Enkanini, a brief introduction to those characteristics through interviewing one resident in Enkanini growing vegetables for himself and his neighbours was given. This resident was considered by the researcher to have the biggest plot of vegetables in the entire settlement. This grower shared his vegetables at no cost with his neighbours when they requested access to them. He did not use fertilisers or pesticides, and he stated that his greatest need for supporting his garden was access to compost.

Participatory public art workshops were run over two days during this research. In these workshops, participants were invited to help paint and co-design a creative and unique map of the settlement. In the map, participants were asked to paint a symbol representing their households and therefore their contribution to the food waste collections. These workshops were done following transdisciplinary methodology, where researchers with different interests and specialisations were invited to facilitate and shape the workshops.

In summary, this case study followed TD methodology motivated by the need for facilitating SL through interactions on the boundaries of different research and practice fields. This was done by investigating and interpreting elements of the Enkanini community that are both human and ecological. Human elements were the food waste collection participants, gardeners, farm owners

and co-researchers. The ecological / biological elements were nutrients, minerals, bacteria and heavy metals contained in soils, compost and food waste. In this way, the varying roles which biological elements play in Enkanini were highlighted. The ways these elements could be integrated into methods for incrementally improving soil conditions and food waste management infrastructure, as well as social behaviour relating to these activities were illustrated. Finally, it is felt that if one wants to include social aspects and participation in food waste collection activities, it is critical that any future options for improvements to food waste management (in Enkanini or elsewhere) should be based on and sensitive to the local context of the community.

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Chapter 5: Analysis of results

"The pessimist sees difficulty in every opportunity, the optimist sees opportunity in every difficulty."

Winston Churchill

1. Introduction

This research was based on the recognition of food waste as a resource for *in situ* composting and nutrient recycling. The research explored and questioned whether efficient waste management and food production strategies are suited to the physical, practical, nutrition and health challenges of informal settlements and their residents. This case study investigated the social learning and participation aspects of improved waste management and service delivery in the form of an ongoing food waste collection project in an informal settlement context in Stellenbosch, South Africa.

Controlled scientific investigations and detailed laboratory testing were done into the nutrient, biological and pathogen concentrations and properties of food waste, compost and soils from in and around the Enkanini informal settlement. Experimental composting with food waste treated with Bokashi EM (Effective Micro-organisms) in the project was done in the settlement using rotating drums. Alternative methods of the cyclic management of food waste such as using it for agricultural feed production and energy and fertiliser production through biodigestion were explored in the research, although to a limited degree.

2. Outline of main arguments of this research

This thesis started with the understanding that soil quality, although often ignored or overlooked, is the foundation of the safety, health and success of any food production activities in any community. The extended pilot project explored a method of composting that offers a practical, simple way for managing domestic kitchen scraps in cramped slum conditions. This method, at the same time, allows a means of increasing the fertility of soil in soils which need it – through composting of food waste and use of effective micro-organisms to do this. The way that the improvement of soil was explored in this case study (via composting) had significant social learning and educational aspects, which were highlighted by their being demonstrated and experienced by collection participants. Participatory art workshops were used to draw attention in a tangible way to these social learning opportunities which are linked to informal settlement upgrading that is sensitive to biological elements in slum environments.

3. Interpretation of results

By exploring the logistical, ecological and social aspects of a number of options for managing Enkanini's food waste, it appears that a combination of management options might offer the best solution for effectively coping with the quantities of food waste generated in Enkanini. The combination of these various management techniques are also considered to represent a more ecologically and socially sensitive approach to tackling the challenges of practising settlement upgrading and UA in informal settlements in South Africa, in contrast to conventional linear or top-down approaches.

a. Composting locally and *in situ* directly into soil

Composting could be done in the immediate surrounding and available spaces in Enkanini by burying food waste (preferably treated with Bokashi EM) directly into any available soil. However, this should only be done in areas where the community agrees to communal use of the space, and in areas where the conditions are safe (e.g. acceptable heavy metal levels and no bacterial risks). It is recommended that these areas be selected with care, and that such selection be supported by rigorous research. This will require various avenues of research to be explored, as well as a detailed and participatory selection process, where interested residents or key representatives of these areas meet with researchers and co-researchers in the Collective to discuss the options available to them. This selection process could be a potentially lengthy process, but is key to the overall success of these spaces.

Newly established gardens could become community-run food gardens, operated and managed, for example, by following a co-operative set-up or arrangement. From a SL perspective, locating these gardens in popular community focus areas such as crèches, schools and churches may assist in facilitating the sharing and understanding of responsibility and benefits of the gardens, especially by those directly participating in them. However, significant investigation into the willingness of these groups and their ability to maintain the gardens would need to be done before establishing such communal gardens. Although this direct soil composting approach appears to be the most ecologically and socially sustainable and representative option for food waste management in the informal settlement context, its feasibility needs to be carefully considered and planned.

b. Composting *in situ* in containers

Compost can be produced using locally available materials in the community or from nearby farms such as weeds, chipped dry branches, chicken and cow manure, as well as food waste. Compost can be used in community gardens (as described earlier in this chapter), or by individuals in their own backyard gardens in Enkanini. These individuals may or may not be participants in food waste

collections. Alternatively, compost could be produced in Enkanini and sold externally, perhaps through a mechanism such as a profit-sharing co-operative, where labour is divided, and where all participants in food waste collections and those who assist in composting activities receive a share of the compost sale profits.

c. Processing of food waste by Black Soldier Fly (BSF) larvae

The use of food waste to feed BSF larvae which are a highly nutritious and valuable agricultural feed and value-added product could be done using food waste supplies from Enkanini. This could be done, for example, on a suitably secured and hygienic site in the nearby Plankenbrug industrial area (situated within walking distance from Enkanini). Residents of Enkanini would need to be trained by specialists, as this is a highly specialised activity.

The BSF larvae could also be used to feed fish such as Tilapia that could be kept in spaces in Enkanini and used for local consumption or sale. In addition, the wastewater resulting from keeping fish such as *Tilapia spp.* (which would be high in ammonia and other nutrients) could be used for irrigation of food gardens nearby, or as a direct medium for growing vegetables hydroponically (e.g. in an aquaponic system). The hydroponic growth of vegetables could be done very simply through the use of a few cheap and locally available materials, and would require little to no energy (e.g. use of solar water pumps if necessary). In this way, mini-ecologies could be set up which mimic the filtering and biomass production characteristics of natural ecosystems.

In addition, one of the by-products that remains after BSF larvae have processed food, the residue of their faeces and indigestible food, can be used to make compost. This compost could be used or sold within the Enkanini community (or elsewhere).

4. Scalability of *in situ* food waste management alternatives in Enkanini

Based on the results from the pilot project of 2012 and this case study, there is indeed interest and willingness in the Enkanini community to continue carrying out food waste collections. Also, participants are generally interested in learning about agricultural activities, perhaps linked to a community garden supported by communal composting from food waste collections, or composting for individual use.

Options for expansion of the food waste collections in Enkanini include:

- Setting up a suitable enterprise by a co-operative of Enkanini residents, to keep the initiative running. This could be led by co-researchers already involved in the food waste collections. Their work could extend to further composting as well as possibly creating and maintaining a participant or community garden (adjacent or close to the existing drop-off centre);
- Obtaining municipal support and investment for increasing the number of food waste drop-off centres (and therefore composting and gardening activities or other value-adding activities) in other zones in Enkanini;
- Setting up non-profit enterprises (employing Enkanini residents) for running collection and composting operations (and possibly gardens) in other areas in Enkanini; and
- Training of selected Enkanini residents on production of compost, Bokashi EM mixtures, vegetables and BSF larvae.

5. Answering the research questions

a. Main research question

The main question which this researcher aimed to answer was:

How can incremental *in situ* improvements in organic waste management strategies support closing the food waste loop in Enkanini?

The answer to this question lies partially in practically and carefully prioritising a locally orientated food waste hierarchy or tool for decision-making in the Enkanini community. This tool would be based on but different to that described by the US EPA earlier in this thesis. In other words, a food waste prioritisation tool can be designed and applied as part of incremental service upgrading options for informal settlements such as Enkanini. Decisions would need to be made as to which management options would be appropriate to the context. In the case of Enkanini, the US EPA waste hierarchy is probably not applicable as it stands. To this end, in the Enkanini context, the researcher suggests that the most efficient and feasible option for use of food waste (kitchen scraps) would be to feed it to animals (or other organisms, such as insects). In this case study, the benefits and practicalities of doing this were explored in relation to feeding food waste to Black Soldier Fly larvae. It was shown that this could be a value-adding enterprise which could be carried out by Enkanini residents. However, this will require a significant amount of training of new staff (as well as intensive and continued input of scientific expertise). This would also require residents involved to have access to a suitably hygienic and convenient area to carry out these activities, and preferably in a location close to Enkanini. Furthermore, it is likely that the most profit would be generated by selling the larvae to farms outside of Enkanini. If larvae are used to feed animals or fish within Enkanini, then this could be an option for closing the waste loop directly within the community.

The husbandry of chickens or fish could be carried out relatively easily and cheaply within Enkanini, as both chickens and fish are hardy and adaptable. They require little space and minimum effort for their upkeep, and they are a culturally acceptable food source. A fish species such as *Tilapia spp.* could be chosen for these purposes, because their water quantity and quality requirements are minimal, and they are very hardy and fast-growing fish. In fact, some *Tilapia* are already being experimentally grown by Agriprotein at their premises in Elsenberg, and are being fed the BSF larvae there. Results from these experiments are not yet available, however. Of course, as value-added products, these chickens and fish could be sold within or outside the Enkanini community.

Another option for food waste management could be using food waste for industrial uses. This is not considered to be feasible in the context of this case study. This is because any kind of industrial activities would presumably require substantial capital investment for machinery and equipment (for example for the drying or pelletising of waste which would be sent on to other processors). This kind of capital is simply not available to communities such as Enkanini. In any case, it is not easily or quickly accessible to residents in the short- to medium- term, which is the time frame necessary for addressing waste management issues in the area.

The biodigestion of food waste could potentially be done in Enkanini, though this was not explored to a great extent in this case study. Nevertheless, the biodigestion of food waste is already possible in the Enkanini community, as a biodigester was installed in 2013 by other researchers in the Collective. The effluent from digestors can be used locally on gardens nearby in the community. However, this method of waste treatment could require significant investment and space. In addition, biodigestors are only able to cope with certain kinds of food waste, so not all food waste would be used. Biodigestion of food waste generates useful products, such as biogas which can be used for cooking. However, the practical and institutional issues and complexities relating to who gets the gas and how this is done would still need to be engineered and solved carefully, practically and sensitively in the community.

Composting of food waste would probably be the next most efficient method of using food waste. As suggested, composting can be done in Enkanini in some of the remaining open spaces around the community, as well as in communal places such as crèches. However, composting can also be done on a household level, where residents could make compost using locally available materials and their own food waste. They could then use their compost to grow food in containers or vertically in or around their living spaces and homes. In the surveys with project participants in 2013, many of these people considered that it would be a good idea to make compost and sell it outside Enkanini. Therefore, this should be considered as a meaningful alternative to simply

attempting to keep nutrients within Enkanini, as the space for doing this is likely to eventually become exhausted.

In summary, efficiently closing the food waste loop would be to first feed food waste to organisms (such as BSF larvae) to produce further inputs into the food system. A second option would be to compost the food waste in the soil or in containers. Given the technical and scientific constraints as well as sufficient and hygienic processing space needed for BSF larvae production, it is suggested that food waste management rather follow composting first, and feeding of food waste to BSF larvae later on, once a suitable skills base has been developed and a suitable processing location has been found.

b. Sub-questions

The guiding sub-questions for the case study investigation were also addressed. The first sub-question was:

What can *real* incremental improvements in waste management look like on the ground for Enkanini residents?

The answer to this question is solution-orientated and relates to the target knowledge about what activities would achieve these kinds of incremental improvements in waste management. It has been shown in this case study that one way this can be done is via development of a regular and trusted service for food waste collections, linked to small-scale communal composting or recycling and value-adding activities of various types. In order to do this, food waste collections, recycling and composting or value-adding activities need to be co-ordinated by existing participants and co-researchers living in Enkanini.

The social aspects of these incremental improvements to food waste management could include camaraderie of participants and their socialising and social interactions with co-researchers or researchers. This was observed in the case study – participants appeared to consider the co-researchers as their neighbours, friends and responsible managers concerned about their welfare and quality of life.

Evidence from this case study to answer this question is largely linked to the status quo of waste collection in Enkanini, and can be used to inform indicators that support an answer to this question. One such indicator found in this case study is that participants in food waste collections stated one of the main improvements (and motivating factors) they experienced from separating and collecting their food waste was a reduction in the occurrence of vermin such as rats in and around their homes. Another characteristic of food waste collections which could be an indicator for an answer to the sub-question, and which was observed in the pilot project of 2012 as well as in this case

study investigation is that participants trusted and relied upon the regular service of household waste collection. Also, participants appeared to become strongly dedicated to this trusting relationship, as well as to their participation in the collections. They began to form household routines associated with the food waste separation and collections, which were shared among the members of their households. The strength of their trust and relationship to collection services was illustrated by their dedication to the regular collections. This was seen, for example, when participants would come to deliver their waste regularly, even in inclement weather or when they had to walk long distances or over difficult terrain.

The second sub-question was:

What can be done to increase the potential social, ecological and educational value of food waste recycling in Enkanini?

The first and most tangible response to this question from a social perspective, and which is part of the transformational knowledge identified in this case study is that the activities of food waste collection can be publicised to illustrate their value. This can be done locally in Enkanini through different media (such as posters and photos) at accessible community points, such as the new Research Centre, or at municipal ablution blocks, churches and spaza shops. An artefact from this research which can be used for this purpose is the illustrated banner painted by participants of the waste collections. By displaying such artefacts in key community points, learning about goals of social and behaviour change, ecological and environmental awareness and education on all these aspects can become more accessible, and seen on a community and personal level. By interacting through different media and activities, the change, awareness and education aspects of food waste recycling and food production should become more accessible to residents.

Ecological and biological aspects of this study suggest that various methods for managing food waste that use or function with biological processes should be promoted to assist in food waste recycling in areas such as Enkanini. Some of these methods include using BSF larvae to produce animal feed, biodigestion of food waste to produce biogas and fertiliser effluent for vegetable gardens, as well as treating food waste with EM and composting it for soil improvement. In order to increase the ecological value of food waste recycling in the area, biological waste management options should be supported as part of service delivery by the municipality, and incremental improvements to these as well. This would also require that residents be assisted with mechanisms allowing them both to participate in the collections, as well as to gain employment and generate value-added products using these biological methods of food waste management.

There may be great educational opportunities for residents of all ages associated with food waste collections. In this way, a wider audience than those directly involved in food waste collections

might be exposed to the ideas and benefits of localised food waste recycling and potential connections to food production. Evidence from this case study which illustrates that this willingness and learning are beginning to take place includes the unprompted emergence of a few project participants (and other residents) requesting compost from food waste collections for use in their own gardens. These could be considered as indicators that these kinds of transformations are beginning to occur. Further to this, the majority of respondents in the participant survey indicated they would like to learn about how to grow their own food. Key role-players in this learning process are and will continue to be the Collective's co-researchers. This is because these co-researchers are directly involved with the waste collection operations (and other linked research experiments in Enkanini), they are learning from and with researchers, and they are involved in the daily lives and realities of collection participants and residents of Enkanini.

The third sub-question for this research was:

What are the main social and physical barriers or challenges to food waste management and food waste recycling in Enkanini?

This question probably lies at the heart of this research – however its answer still remains enigmatic. In terms of social acceptance of food waste management in the settlement, if this were to be carried out by the municipality, one of the main challenges could be the apparent general distrust in the community of the municipality, especially in matters related to service delivery. This distrust may be a result of the lack of formal recognition of the area as a settlement and its subsequent infrequent or limited service provision. There have recently been several violent service delivery protests from Enkanini's residents in this regard.

In terms of physical challenges to food (and general) waste management in the area, the steep and often slippery topography makes it difficult for collection trucks to drive through Enkanini to the existing municipal waste skips. Currently, the food waste in bags left in municipal skips is the principal reason for attraction of vermin and pests (rats and scavenging dogs) to the putrefying waste. Separating food waste and collecting this separately in numerous accessible and convenient hubs around the settlement would reduce the amount of general waste the municipality has to collect, making their collections practically and logistically easier. However, specialised food waste collections on a large scale would face similar challenges, as vehicles would most likely be needed. The use of bicycles and trailers for moving food waste to collection hubs could ease these challenges. However, the cramped nature of the settlement, drainage challenges, steep slopes and lack of roads means that any kind of waste collection project will still, to a certain degree, rely on people walking and carrying their waste to collection sites or collecting it from participants.

A further question which this research sought to investigate was:

Can ecosystems services be harnessed in a limited space (such as composting of food waste in containers or in small garden patches)?

The answer to this question was explored in this research through experimenting with local *in situ* container composting, by considering composting directly into the ground (in the pilot project of 2012), as well as considering options of feeding food waste to BSF larvae or decomposing it in biodigestors. The ecosystems services of nutrient decomposition and recycling can be enhanced through the use of Effective Micro-organisms (EM), such as those found in Bokashi. These EM were thus just one tool explored in the toolbox for waste management options that exist in the settlement. In order to determine the effectiveness of the EM as a tool, as well as that of contained ecosystem services, the safety and quality of food waste treated using EM was investigated in this research. Compost generated from Bokashi EM food waste as well as residue resulting from BSF larvae processing of food waste was also tested for the same purposes.

In order to put the results of contained Bokashi EM and ecosystems services into perspective, the qualities of soils in and adjacent to vegetable beds that had used compost made from Bokashi-treated food waste for years were tested (Legacy Garden in Kayamandi). The soils adjacent to the vegetable beds were assumed to be the 'pre-project' conditions i.e. the conditions before use of Bokashi compost. These tests were done to determine whether EM can help to improve soil quality via the ecosystems services they provide or encourage. It was confirmed that the vegetable beds using Bokashi compost did, in fact, have a higher soil fertility level. Although the sources of possible soil improvement were not investigated in any detail, it was assumed that at least some of this fertility was due to the use of Bokashi compost (and therefore of the ecosystems services of EM therein), as no artificial fertilisers were used in the garden.

In addition, composting was carried out in large rotating drums, using food waste treated with Bokashi EM. This compost was compared to compost prepared in the same way, with the same ingredients, but without any food waste at all. The compost containing Bokashi-treated food waste had higher moisture and mineral levels (such as of iron and zinc), although the food waste had not been completely decomposed. This compost was, however, considered to be of better quality for plant (vegetable) growth because of its characteristics and mineral content. Thus, it seems possible to that some ecosystems services can be used in the biological treatment of food waste, and in the context of the limited space of the informal settlement. However, this needs to be explored and tested further, especially in the cases of BSF larvae production and biodigestion of EM treated food waste, due to their space and technical requirements.

The final sub-question which assisted the direction of this research was:

Can nature's recycling processes be mimicked incrementally in an informal and cramped environment?

In this question, the phrase 'mimic nature's recycling processes' refers to the way nature manages waste, which is a more cyclic process, where waste from one stage or part of the ecosystem is an input for another stage or element of the ecosystem. In other words, the question asks how we can try to imitate (in small steps) the efficient and circular ways that nature reuses waste. Nature does this, for example, through the activities of bacteria and micro-organisms, which are able to feed on waste and generate useful products such as accessible minerals and nutrients. These products then become essential inputs for plants for their growth. Thus, waste becomes re-used and processed in a natural cycle. In this thesis, completed cyclical processes may not have been imitated, but natural processes are considered to have been used in certain parts of managing the food waste in Enkanini.

All the options for managing food waste explored or suggested in this research represent ways of mimicking nature's ability to recycle waste (e.g. biodigestion, composting and larvae processing of food waste for production for agricultural feed). Also, all these options generate products which can be used in other processes, and they appear to complement each other. This means that no single option needs to be followed as a waste management strategy for the community. This therefore suggests that the options explored have potential for being included in incremental designs for waste management improvement. The options also follow design principles that could potentially maximise and enhance the natural environmental conditions which nature provides freely, even in the highly modified context of an urban slum.

In line with the aims of the Collective, it is necessary to innovate the outcomes of this research. One suggestion for how this can be done is to consider how steps can be taken to improve food waste management in Enkanini by incorporating it into the design of the iShack and sanitation experiments in Enkanini, for example. For the iShack, this could be done through the use of vertical gardening, container planting and composting, as well as by using green roofs and 'vertical food walls' (which are also useful for insulation and fire-resistance in shacks) (see Design Indaba Website, 2013). In terms of sanitation options, food waste treated with Bokashi EM can be added to biodigestors and the effluent waste used in nearby gardens.

Evidence from this case study which illustrates how nature's recycling processes were harnessed incrementally includes the small-scale container composting that was done in rotating drums. The Bokashi EM which were used as a pre-treatment method for food waste preparation for composting and subsequent soil improvement also relied on natural processes. These processes

included the ability of natural organisms to begin breaking down the food waste. The use of Bokashi EM to treat waste was shown to reduce the pathogen content over time on fermenting food waste in storage drums. This shows that the EM were fulfilling their role of naturally competing with pathogens, and that this was possible even in the limited space of the food waste drums. These various contained natural processes and activities were considered to be incremental because of their potential and flexibility for being scaled-up, modified and replicated in Enkanini and elsewhere. The answer to this question is therefore positive.

6. Transdisciplinary knowledge sets explored in research

In this research, some of the elements of social, technical and cultural change processes relating to the feasibility of options for incremental food waste management in Enkanini were investigated. Some of the possibilities for how this can be done in the informal settlement context were illustrated. This was done in order to highlight and enable a shift from the current (unsustainable) systems to transformed (sustainable) systems for waste management, UA and food production.

a. System knowledge

The empirical knowledge which was produced in this research included that relating to the practical, health, safety and biological aspects of composting, soil quality and soil nutrients. This was done by using Effective Micro-organisms (EM) as part of the biological toolbox for food waste management in the case study. The understanding of interacting factors in this thesis included observations of the interactions of existing soil conditions with nutrients and bacteria - as well as the social interactions of co-researchers, residents, participants and researchers.

With respect to how empirical knowledge and understanding of interacting factors can be interpreted in the life-world, aspects such as how to make decisions about the safety and value of food waste and composting emerged from the research. In addition, it was demonstrated how decisions needed to be made about soil quality in relation to acceptable limits for human health. Other ideas and interpretations included the need to determine the real feasibility of using Bokashi EM to treat food waste in this informal settlement context, as well as the potential for generating value-added products, calculating the impacts of removing food waste from the municipal waste stream and the potential for these activities to be scaled-up.

b. Target knowledge

Target knowledge is related to communicating and explaining the need for change in a system or situation. In this case study, how the municipality currently manages waste in Enkanini (and in general) was identified as a key subject for the need for change in the status quo. The details of what this kind of change would involve were not explored in this thesis extensively. The reasons for

this are twofold: the researcher was constrained by timeframes for the research process, and officials had limited time to dedicate to the subject. Nevertheless, there is a need to challenge and confront the reactive rather than proactive methods used to manage waste in general, as well as the general acceptance of the lack of regular service delivery for waste collection in the Enkanini area and other informal settlements.

It is suggested that the Stellenbosch Municipality continue to take further steps in addressing its landfill space crisis in order to achieve the stated goal to be the 'greenest municipality'. It should do this by focussing on the low-hanging fruit of food waste separation at source. This, as well as subsequent composting and recycling of food and organic waste needs to be considered seriously as an option for waste management in the municipality. The biological and ecological options explored in this case study for food waste management exist as solutions in both informal settlements and in formal residential areas in the municipality.

Target knowledge also focuses on how we need to work out the need for change. This can be done by using evidence from case studies such as the one explored in this thesis. The importance of interactions with residents in the areas directly affected by or participating in incremental upgrading of service delivery is critical to developing the case for government consideration of such projects.

Working out the need for change involves considering the need for better practices within a system. One example of where this needs to be done is the municipality's apparent lack of safe and appropriate waste management at the Stellenbosch landfill. This is because the municipality has, for some time now, not complied with the environmental, health and safety regulations for the landfill's height and management conditions.

c. Transformation knowledge

Transformation knowledge is related to the understanding of the range of ways that we can act to change existing processes. This change can be social, technical, cultural or legal.

During this research, the following observations in the Enkanini community relating to these categories of change were made:

- Social change – routine domestic waste management behaviour was encouraged and generated through the introduction of the pilot project in 2012. This was reinforced recursively through the continuation of collections in 2013. Participants began to rely on regular collections of food waste, and started to react to this because they appreciated the incentives and benefits of participation. These benefits included improvements in living conditions, a lower incidence of vermin, an increased awareness of organic resources,

social learning for more sustainable living systems and the understanding that the community could and should be an active player in its own service delivery needs.

- Technical change – the introduction of the use of EM and collection of food waste for composting means that although on a small-scale, Enkanini became more ecologically efficient than it was before the food waste collection projects. This efficiency is considered in terms of the possibility to use various methods for closing the waste and nutrient cycle in the settlement and by generation of value-added products that could be exported from the community.
- Cultural change – it is believed that progress has been made in terms of improving recognition of the value of food waste and the perception of different ways of managing food waste amongst co-researchers and participants in the project. This was done through the regular and continued waste collections, and the demonstration of container composting and its demonstrated local use. Also, residents participating in collections were exposed to ways of looking for opportunities for making meaningful incremental adjustments to their living conditions.
- Legal change – this kind of change will ultimately be achieved if this food waste recycling is included in the municipality's objectives for solid waste management in informal and formal settlements in the area, as it could become part of their policies. Ideally, change will be possible if there is municipal acceptance of the role and impacts of projects such as that carried out for this thesis. In addition, if the potential for such projects to be scaled-up is recognised by the municipality, further changes can be achieved in its waste management codes. Finally, one of the biggest impacts which legal change can have on the separation and use of food or organic waste in municipalities throughout South Africa will be felt upon the introduction of legislation which prohibits sending organic wastes to landfills.

To summarise, the knowledge sets that this study primarily focussed on were the social, technical and cultural change processes needed for instigating change in the food system, and specifically in changes in aspects of food waste management in a local municipality. The aspects and characteristics of legal and institutional changes were not explored in great detail in this study. These two areas are therefore suggested as focus areas for future research into continuing long-term and lasting change and transformation in the food system in general.

7. Conclusions

A number of alternatives for managing food waste treated with Bokashi EM in Enkanini have been considered in this research. Composting of food waste in rotating drums is a useful way of managing the waste, though the numbers of drums available to the researcher were not able to cope with the quantities of food waste flows of the project. More rotating drums (or similar) will be needed to determine the real ability of container composting methods to deal with the waste

quantities and flows of such food waste collection projects. Nevertheless, the main points encountered in this case study - the SL and educational values of the demonstration of composting and food waste collection activities - are considered to be highly important and relevant to this kind of upgrading work. The key learnings in the thesis are that because of its immersive nature, it can be argued that the technological and logistical details may not be as important as aspects such as the experience of regular and improved service delivery, social learning, and practical application and demonstration of frameworks which were built and encouraged with co-researchers and participants in the case study.

Before this project can be up-scaled or replicated, it is vital that the technical and practical issues which proved to be challenges in this research be addressed. These include the storage and transportation of food waste (including deciding whether transport is needed at all), the maintenance of anaerobic conditions for the food waste, the handling of food waste, as well as the consideration of ways for addressing how to reduce costs of critical inputs, such as of the Bokashi EM.

Such practical or technical issues can be addressed as follows:

- Ensuring that food waste collection drums are tightly sealed and as full as possible before closing them;
- Having a large number of 120 litre collection drums, so that the standing time for full drums is not longer than 1 week;
- Increasing frequency of waste collection by Agriprotein, nurseries or similar (if waste still needs to be exported from Enkanini);
- Ensuring the possibility of using food waste for a number of options remains flexible;
- Carrying out regular laboratory testing of waste samples and any value-added products generated;
- Doing routine cleaning of collection centres; and
- Ensuring there are continued and increased learning opportunities with technology partner/s, such as ProBiokashi (Pty) Ltd., for example about how to make EM on a household or small-scale.

In this case study, most of the food waste was exported to agricultural feed production facilities and nurseries outside of Enkanini. Alternatives that would keep this food waste within the community include:

- composting of food waste into available open areas to support vegetable gardening;
- fermentation of food waste in local biodigestors;
- use of biodigester effluent as fertiliser local gardens; and
- production of BSF larvae for feeding to chickens and/or fish in the community.

It may be inferred from this investigation that the most realistic, ecologically sensitive and cost-effective alternative to exporting food waste from Enkanini will be a combination of container (drum) composting activities, direct composting into available soil and gardens in Enkanini, as well as the disposal of Bokashi-treated food waste into local biodigestors. As and when resources and capacity have been built-up, and when feasible, agricultural feed production activities (i.e. the production of BSF larvae) is more likely to generate more jobs and a better financial income stream from the sale of larvae than the other composting or recycling options.

The Bokashi EM was the most expensive part of the running costs of the food waste collection project (apart from co-researcher remuneration). If the municipality or other potential funders decide to continue using Bokashi EM in food waste management in such projects, the most significant method for reducing running costs will be to train and employ suitably qualified candidates to produce the Bokashi EM closer to Enkanini. They could even train residents to do this on a household level. In the longer-term, this approach would be cheaper than current costs of buying ready-made Bokashi EM. It would be possible and feasible to do this, but only after obtaining a culture of EM, permission and recommendations from the technology partner, ProBiokashi (Pty) Ltd.

To summarise, there is a need to determine how to convert this food waste collection project into a small- or medium-scale enterprise with income generating capacity. This needs to be done by generating income flows e.g. for waste collection services (a service charge to higher-income areas that may participate in collections), from the sale of value-added products (such as compost, agricultural feed, or vegetables grown using the food waste). All this will need to be calculated in a sufficiently detailed model and business plan, and will need to be implemented in phased stages (see Appendix 8 for a description of these suggested stages).

Chapter 6: Discussion and Conclusion

"You cannot understand a system until you try to change it."

Lewin, 1946

1. Introduction

This thesis used a case study to illustrate how some biological elements interacted with different parts of their environments in a slum in South Africa. It also illustrated how changes which they can have on their environments can be tracked scientifically. In addition, the case study tested and provided a practical example of how these biological elements could also be used to improve the domestic hygiene and comfort of urban informal settlement residents by making their food waste safe to store and recycle into various other products. In this way, the case study illustrated the potential which such biological elements have to contribute to improving the overall environmental and health conditions in informal settlements. This was demonstrated through the potential of biological elements to improve soil conditions, as well as to reduce vermin attraction to waste stored in households, and to reduce the amounts of festering food waste in municipal waste collection areas.

2. Social learning for sustainable food waste management and Urban Agriculture

The food waste collections for this case study as well as the pilot project of 2012 illustrate how incremental improvements in waste management services can be carried out in informal settlements. These improvements were made by continuing to grow and develop a relationship with and the trust of a group of residents. These residents began to make collecting food waste and separating it in their homes a part of their domestic routines. Participants in collections were able to see that they could rely on the researcher and co-researchers in the Collective to provide reliable and regular assistance with managing their household food waste. The willingness of participants to be a part of the collections, their trust in the regular provision of a service (the costs of the service were borne through research grants), and their ability to alter their behaviour to follow a routine are seen to be the key elements contributing to the success of the project.

The behaviour of food waste collection participants can be interpreted in a number of ways in relation to SL theory. These include:

- The occurrence of learning at different levels – among individuals and in communities of practice (the community of residents participating in the food waste collections);
- The continuous engagement of participants with co-researchers and the researcher during regular food waste collections (e.g. informal chatting, greetings, sharing of thoughts, ideas, stories and concerns);
- The engagement of participants with each other, in terms of carrying out the collection activities together, as well as talking about and making artefacts to represent what they had learned. In this study, the artefact which they made together (the banner map) represented their determination and positivity towards food waste collection and improved services. In this way, participants were able to imagine their community differently, as well as to experience, share and express these imaginings in surprising, colourful and creative ways.

3. Research limitations

It is necessary to flag a number of limitations of this research, in order that they may be explored in more detail in further research. The first of these is a lack of investigating the reasons as to why there was a significant reduction in the number of participants between the 2012 and 2013 projects. Although some reasons for this were speculated upon in the thesis, the researcher feels that this topic was not explored in sufficient detail. Further investigations or interviews with both the 2013 and 2012 project participants would be needed to determine the key aspects of collections which made them continue or stop participating.

Also, the researcher was only able to interview one person carrying out food gardening in Enkanini. Therefore, this aspect of the research should not be considered as an actual indicator of the level of activity in food gardening in general in the area. Furthermore, although other small food gardens were observed around the settlement by the researcher, none of these residents were interviewed regarding aspects of their food production. The researcher feels that this would be key information specific to Enkanini which would be of great importance in determining the viability of UA projects, and in turn that of the possible benefits of UA in the area.

Another limitation of this thesis is that there was no detailed financial modelling done relating to the various waste management options and the scaling-up of these operations. This kind of costing, which could be done in a similar way as that which was done for the power costs associated with the iShack (i.e. energy use costs and savings from solar power units), is vital to the progression of these food waste collections. This kind of modelling would need to include a breakdown of all the benefits and costs to the key actors that would be involved in food waste management collections.

4. Recommendations

a. Further laboratory testing

It is recommended that future studies be done to determine the strains of *E. coli* found in samples tested in this study. If the strains are harmful, the source of contamination should be determined and necessary precautions taken immediately for the sake of those involved. Bacteria levels need to be carefully monitored into the future for these kinds of food waste collections, to reduce possibilities of the food waste harbouring or spreading harmful bacteria.

Technical issues related to food waste storage and transport (such as sealing and movement of full storage drums) will need to be streamlined in further research. This will be critical, especially if collections are expanded. This is also necessary in order to iron-out food waste processing challenges and bottlenecks. If food waste is placed in biodigestors (such as the one at the Research Centre) in Enkanini, it will be important to test the safety and quality of effluent from the digester before endorsing its use as a fertiliser for gardens (in Enkanini or elsewhere). It will be equally important to monitor the quality and safety of any compost made from food waste in future activities (in Enkanini or elsewhere).

b. Practical aspects

As a response to the challenge of topography in Enkanini, setting up a number of food waste recycling hubs or drop off centres at more easily accessible points around the community could help to reduce the volumes and weight of waste that the municipality has to collect. This could also reduce the frequency of municipal waste collections and simplify the kinds of trucks needed for collections. Having such focussed collection points could also allow the municipality to have more organised and established areas for general waste collection around the settlement. This could, in turn, facilitate and encourage further on-site separation of waste to contribute to the municipality's greening and recycling initiatives, as well as the potential for job creation.

c. Investigate resident willingness for continued participation

The food waste collections carried out in this project represent a pro-active and participatory form of incremental improvements to waste management service delivery in an under-serviced informal settlement. Further social surveys need to be done in Enkanini to determine the true scalability of the project in the settlement. Surveys in other areas need to be done to determine the collection model's replicability. It is important to be cognisant of the contexts and locations of informal settlements and the roles that these aspects play in contributing to the success (or failure) of social enterprises and skills development projects that are located in such settlements. Furthermore, social surveys in more formalised and higher income areas also need to be done before similar food waste collections can be carried out in such areas.

All such surveys need to efficiently and clearly determine the needs, expectations and attitudes of residents involved. In the Enkanini collections, future work will also need to explore possible incentives and opportunities for residents to become more fully involved in the design and incremental additions to communal activities associated with food waste management. If or when it is decided to expand collections from Enkanini to other areas, it is suggested that similar surveys and pilot projects such as those carried out in 2012 and for this case study be carried out before fully implementing waste collection activities.

d. Financial modelling, planning and support

In order to provide a case to the municipality (or other potential funders) to justify expansion of this project, it will be necessary to draw up a budget detailing the start-up and running costs of different expansion options. Detailed financial modelling was not done in this thesis, as it was beyond the scope of the research given the time constraints of the researcher. This modelling and planning will need to be done in the form of a phased action plan which the funders could consider and, if deemed feasible, adopt. This phased plan could involve the scaling-up of this case study project, first in Enkanini, and then beyond to other informal settlements and more established settlements elsewhere in the Stellenbosch Municipality. This could be done by increasing the numbers of households participating in each settlement, as well as increasing the number of collection points for the waste and the necessary transport arrangements that this would most likely require.

5. Conclusion

The main observation which stood out throughout this study was the value of and continuous need for fostering relationships with residents and co-researchers, as well as the emergent trust that participants had for regular service provision. This is likely to have occurred because of collection activities being run and managed by co-researchers who are Enkanini residents themselves, and therefore not seen to be 'outsiders' or municipal or government employees.

The participant banner painting workshops and their associated activities were able to effectively illustrate the value and spatial dynamics of these relationships in the mapping exercise. The workshops provided an unusual 'safe space' and neutral ground for residents involved in the collections to participate in a creative group activity, which could be the first time something like this has been possible for many of them. Also, the workshops allowed residents to realise that the impacts of their participation extended beyond the benefits to, activities in, and behaviour of their own families and households. The workshops provided an opportunity for participants of all ages to meet up and interact with each other, and encouraged them to feel a kind of 'creative camaraderie'. Such relationships can encourage interactions for community co-operation and co-production of incremental innovations which are appropriate to developing solutions to all types of service delivery challenges in informal settlements, both in South Africa and elsewhere.

In a more general sense, it is imperative that we recognise that sustainable economic, environmental and social development can only happen if cities become included and integrated into South Africa's strategies for development and food security (McLachlan & Thorne, 2009:12). This inclusion needs to be done starting from the household level, progressing to higher levels (McLachlan & Thorne, 2009:12).

Finally, in order to achieve real co-production for 'incremental urbanism' done by government, communities and the private sector, these players will need to rely on researchers who co-produce 'socially useful knowledge with the most marginali(s)ed and poorest sectors of society' (Swilling *et al.*, 2013:11). Or, quite simply, as Helen Keller said, 'alone we can do so little; together we can do so much'.

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Appendices

Appendix 1: Soil test results

Table 1: Nutrients

Sample site	Soil type	pH (tested with KCl)	Resistance (Ohms)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	Fe (mg/kg)
Legacy Bed	Loam	6,6	830	3,18	38,4	17,4	0,44	88,01
Legacy Soil	Loam	6,9	430	3,21	19,6	13	0,46	54,46
Ishack Soil	Loam	5,1	850	1,68	19,6	120,5	0,73	115,55
Ishack Veg	Loam	6,5	1070	2,04	16,7	128,3	1,15	98,1
Polla Park Bed	Loam	5,3	530	3,18	9	132,1	0,41	115,13
Polla Park Soil	Loam	5,2	1130	1,74	2,1	134,1	0,16	65,2
Shack Soil	Clay	7	510	0,77	8,5	7,6	0,34	19,21
Centre Soil	Loam	5,9	860	3,1	145,2	28,6	0,9	90,02

Appendix 1 - Table 2: Bacteria in soil samples

Sample site	Total Bacteria/1g	Coliforms/1g	<i>E. coli</i> /1g	Salmonella (per 25g sample)
Legacy Bed	110 000	>24196	10	Not detected
Legacy Soil	129000	>24196	<1	Not detected
Ishack Soil	52000	2481	<1	Not detected
Ishack Veg (bed)	464000	>24196	323	Not detected
Polla Park Bed	113000	>24196	1178	Not detected
Polla Park Soil	38000	3076	<1	Not detected
Shack Soil	36000	>24196	10	Not detected
Centre Soil	133000	>24196	197	Not detected

Appendix 1 - Table 3: Heavy metals in soil samples

Sample site	Cd	ACCEPTABLE	Pb	ACCEPTABLE	As	ACCEPTABLE	Hg	ACCEPTABLE	Sb	ACCEPTABLE
	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	
Legacy Bed	0	< 1.8	2,44	< 50	1,42	< 10	0	< 0.13	0,25	< 1,0
Legacy Soil	0	< 1.8	3,33	< 50	2,45	< 10	0	< 0.13	0,86	< 1,0
Ishack Soil	0	< 1.8	4,2	< 50	0,95	< 10	0	< 0.13	0,16	< 1,0
Ishack Veg (bed)	0	< 1.8	2	< 50	1,21	< 10	0	< 0.13	0,24	< 1,0
Polla Park Bed	0	< 1.8	2,13	< 50	1,58	< 10	0	< 0.13	0	< 1,0
Polla Park Soil	0	< 1.8	0,71	< 50	1,25	< 10	0	< 0.13	0	< 1,0
Shack Soil	0	< 1.8	1,57	< 50	2,83	< 10	0	< 0.13	0,62	< 1,0
Centre Soil	0,01	< 1.8	1,41	< 50	2,58	< 10	0	< 0.13	0,67	< 1,0

Appendix 2: Compost test results
Table 1: Nutrients

			Moisture	Density	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B	C	Ash
Sample site	pH (tested with KCl)	Resistance (Ohms)	%	kg/m ³	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%
Agripro Old Manure	6,6	50	57,7	568,7	2,85	1,88	4,57	1,76	0,62	15785	84,06	1805,9	153,74	354,99	34,41	32,78	27,2
Eric Vermi	6,7	140	79	785,8	2,01	0,56	0,16	1,55	0,25	280,53	162,5	3711,5	19,67	138,21	15,45	24,47	46,85
Agripro Res 1	6,6	80	14,8	232,1	3,05	1,31	2	2,93	0,53	5767,6	162,65	2848,6	103,15	443,28	21,95	37,3	27,8
Spier Compost	7,2	100	25,2	789,8	0,67	0,16	0,79	1,05	0,17	618,14	61,43	6556,5	13,27	39,23	15,68	5,17	80,05
Knorhoek 2-New	6	120	31,4	960,1	0,64	0,13	0,25	0,61	0,07	538,63	114,86	10457	10,95	35,29	11,05	5,12	87,85
Knorhoek 2-Old	6,1	270	34,1	823,6	1,29	0,17	0,43	1,02	0,16	709,59	137,36	9255,7	18	55,11	21,11	12,1	71,8
Bok Com	6,1	70	50,9	921,6	0,94	0,21	0,4	0,33	0,08	1281,6	44,95	10561	7,7	50,54	6,46	9,95	72,45
Non Bok	6,8	80	48,7	898,6	0,76	0,13	0,46	0,39	0,12	511,43	52,89	9920,9	8,16	46,46	8,91	6,44	79,15
Soil Centre Crate	6	430			0,291						54,6		7,69	291,4	0,53		
Compost Centre	6,9	300									63,73		13,05	53,99	11,52		

Appendix 2 - Table 2: Bacteria

Reference	Total Bacteria/1ml	Coliforms/100ml	<i>E. coli</i> /100ml	Date	Salmonella
No.				Tested	/25g
Agripro Old Manure	1 500 000	>24196	>24196	2014-06-13	Not detected
Eric Vermi	130 000	>24196	146	2014-06-13	Not detected
Agripro Res 1	>3000 000	>24196	>24196	2014-06-13	Not detected
Spier Compost	310 000	>24196	10	2014-06-13	Not detected
Knorhoek 2- New	>3000000	>24196	>24196	2020-06-13	Not detected
Knorhoek 2- Old	160000	>24196	51	2020-06-13	Not detected
Bok Com	500000	>24196	>24196	15/07/2013	not detected
Non Bok	900000	>24196	>24196	15/07/2013	not detected
Soil Centre Crate	440000	24196	>24196		Not detected
Compost Centre	250 000	>24196	110		not detected

Appendix 2 - Table 3: Heavy metals

Reference	As		Pb		Sb		Cd		Hg	
No.	mg/kg	Acceptable								
Agripro Old Manure	0,103	< 10	0,356	< 50	0,185	< 1,0	0,057	< 1.8	0	< 0.13
Eric Vermi	0,763	< 10	1,261	< 50	1,04	< 1,0	0,112	< 1.8	0,166	< 0.13
Agripro Res 1	0,206	< 10	0,177	< 50	0	< 1,0	0,051	< 1.8	0,029	< 0.13
Spier Compost	0,653	< 10	1,473	< 50	0	< 1,0	0,18	< 1.8	0,321	< 0.13
Knorhoek 2- New	3,573	< 10	5,518	< 50	0,769	< 1,0	0,085	< 1.8	0,058	< 0.13
Knorhoek 2- Old	1,655	< 10	0,232	< 50	0,052	< 1,0	0	< 1.8	0,064	< 0.13
Bok Com	0,4	< 10	3,75	< 50	0,07	< 1,0	1,6	< 1.8	0	< 0.13
Non Bok	0	< 10	3,11	< 50	0,33	< 1,0	0,82	< 1.8	0,01	< 0.13
Soil Centre Crate	3,17	< 10	2,75	< 50	0,05	< 1,0	0,03	< 1.8	0	< 0.13
Compost Centre	2,073	< 10	2,61	< 50	0,191	< 1,0	0	< 1.8	0	< 0.13

Appendix 3: Solid and Liquid Food waste test results**Table 1: Nutrients**

Reference No.	pH	Resistance ohm	Moisture %	Density kg/m ³	N %	P %	K %	Ca %	Mg %	Na mg/kg	Mn mg/kg	Fe mg/kg	Cu mg/kg	Zn mg/kg	B mg/kg	C %	Ash %
Food Waste New	4,2	60	67,8	980,7	1,77	0,6	0,78	0,71	0,15	4631,37	32,14	725,19	6,05	36,47	4,83	41,16	56,3
Food Old	3,8	60	75,3	923,1	2,41	0,65	0,89	0,96	0,19	5201,6	30,73	380,06	4,09	36,09	4,77	41,42	6,95
Liquid food waste (small tub)	3,8	60	96,9	1,09	0,18	0,06	0,13	0,04	0,08	515,52	2,42	45,38	0,98	3,43	1,09	1,4	0,85
Liquid food waste (large bottle)	3,7	50	97,1	0,85	0,14	0,06	0,14	0,03	0,09	488,49	3	17,29	0,97	3,23	1,03	1,63	0,7

Appendix 3 - Table 2: Bacteria

Reference No.	Lab. No.	Coliforms/1g	<i>E. coli</i> /1g	Total Bacteria/1g	Date Tested	Salmonella /25g
Food Waste New	286	>24196	>24196	2 960 000	2017-05-13	not detected
Food Old	337	>24196	>24196	1 590 000	2014-06-13	Not detected
Liquid food waste (small tub)	2155	>24196	>24196	>30 000	2014-06-13	Not detected
Liquid food waste (large bottle)	2156	>24196	>24196	>30 000	2014-06-13	Not detected

Appendix 3 - Table 3: Heavy metals

Reference No.	Cd mg/kg	Acceptable	Hg mg/kg	Acceptable	As mg/kg	Acceptable	Pb mg/kg	Acceptable	Sb mg/kg	Acceptable
Food Waste New	0,018	< 1.8	0	< 0.13	0	< 10	0,016	< 50	0	< 1,0
Food Old	0,009	< 1.8	0,053	< 0.13	0,608	< 10	0,18	< 50	0	< 1,0
Liquid food waste (small tub)	0,003	< 1.8	0	< 0.13	0,036	< 10	0,031	< 50	0,128	< 1,0
Liquid food waste (large bottle)	0,001	< 1.8	0	< 0.13	0,031	< 10	0,005	< 50	0,09	< 1,0

Appendix 4: Questions in food waste collections interviews

1. What town and province were you born in?
2. What is your sex? a) male b) female
3. How old are you?
 - a) 18 – 22 years b) 23 – 30 years c) 31 – 40 years d) 41 – 50 years
 - e) 51 – 60 years f) older than 60 years g) prefer not to answer
4. How many people are there in your household including you?
 - a) 1 b) 2 c) 3 d) 4 e) 5 or more f) prefer not to answer
5. How often do you bring your Bokashi bucket to collections?
 - a) once per week b) every 2 weeks c) every 3 weeks d) once per month e) less than once per month f) not sure g) prefer not to answer
6. How often do you have to get more Bokashi to fill your packet?
 - a) every week b) every 2 weeks c) every 3 weeks d) once per month e) less than once per month f) not sure g) prefer not to answer
7. Have you ever learnt anything about growing crops / vegetables / fruit? a) yes b) no c) cannot remember d) not sure e) prefer not to answer
8. If yes to 7, how did you learn about this?
 - a) Practiced it myself b) watched my family do it c) learnt about it at school
 - d) saw it on TV e) prefer not to say f) other
9. Do you want to learn about growing your food? a) yes b) no c) not sure d) prefer not to answer
10. In the past month, where have you most often bought or got your fresh food from?
 - a) supermarket b) other market c) street vendor d) spaza shop
 - e) friends f) farm g) not sure h) other i) prefer not to answer
11. How often do you buy or get fresh fruit or vegetables?
 - a) every day b) every 2 days c) every 3-4 days
 - d) once per week e) less than once per week f) not sure g) prefer not to answer
12. How do you store your fresh food? (you can choose more than one answer)
 - a) shelf b) cupboard c) fridge d) boxes e) packets f) other
13. Do you have any problems when you store your food? a) yes b) no c) not sure d) prefer not to answer
14. If yes to 13, what kind of problems do you have? (you can choose more than one answer)
 - a) food gets old quickly b) it attracts rats and other pests c) not enough space d) other e) not sure f) prefer not to answer
15. What is your biggest difficulty in cooking food?
 - a) no electricity b) fuel needed for other uses e.g. lighting and heating
 - c) not enough time d) other e) not sure f) prefer not to answer
16. What is your biggest difficulty in getting food?
 - a) supermarket is far away b) food is expensive c) difficult to carry food home
 - d) irregular income e) other f) not sure g) prefer not to answer
17. How much do you spend on fresh food per week?
 - a) R1-20 b) R21-40 c) R41-60 d) more than R60
 - e) not sure f) prefer not to answer
18. What do you think about having a community garden and gardening activities (e.g. composting) in Enkanini? (e.g. useful, good idea, not interested, work is too hard etc.)
19. Do you have any problems with your rubbish at home?
 - a) yes b) no c) not sure d) prefer not to answer
20. If yes to 18, what kind of problems do you have (you can choose more than one answer)?
 - a) smells b) pests e.g. rats c) no space
 - d) skip is far away e) no container to keep it in f) other g) not sure h) prefer not to answer
21. Why did you decide to collect your food waste?
22. What kind of food do you throw away the most of?
23. What are some advantages of collecting food waste?
24. What are some difficulties / disadvantages of collecting food waste?
25. Do you want to exchange something for your food waste?
 - a) yes b) no c) maybe d) not sure e) prefer not to answer

26. If yes or maybe to 24, choose 3 of the most useful things to you in exchange for your food waste from the choices below:
- a) soil (compost) and containers to grow your own food
 - b) fresh fruit or vegetables
 - c) vegetable seedlings for you to grow at home
 - d) school items for your children
 - e) toys
 - f) dry food products e.g. pap, rice, beans
 - g) airtime
 - h) clothes
 - i) money
 - j) braai or party with other Bokashi collectors
 - k) other
27. Do you know what compost is?
- a) yes
 - b) no
 - c) not sure
 - d) prefer not to answer
28. What do you think we should do with food waste?
- a) nothing
 - b) put it in normal rubbish
 - c) make soil (compost)
 - d) make soil (compost) to use in a community garden in Enkanini
 - e) feed animals in agriculture
 - f) other
 - g) not sure
 - h) prefer not to answer
29. If you selected c or d in question 27, who do you think should make soil (compost)?
- a) co-researchers
 - b) Municipality
 - c) residents in Enkanini that collect food waste
 - d) farmers
 - e) private companies
 - f) Non-governmental Organisations
 - g) a combination of some or all of these people
30. What do you think are the 3 most important things for continuing collecting food waste?
- a) family involvement
 - b) learning together
 - c) socialising with friends
 - d) less pests (e.g. rats, flies)
 - e) regular exchange or rewards e.g. Braais
 - f) keeping Enkanini cleaner
 - g) making friends
 - h) meeting with co-researchers
31. How did you learn about the Bokashi food waste collection project?
- a) loudhailer (co-researchers)
 - b) friend
 - c) family member
 - d) neighbour
 - e) other
32. What things do you think are needed to make soil (compost)?
33. Do you know anyone in Enkanini that has some of these things mentioned in question 29?
- a) yes
 - b) no
 - c) not sure
 - d) prefer not to answer
34. If soil (compost) were made in Enkanini, do you think it should be sold outside of Enkanini?
- a) yes
 - b) no
 - c) not sure
 - d) prefer not to answer
35. Do you think there is enough food waste in Enkanini to make soil (compost) and a community garden?
- a) yes
 - b) no
 - c) not sure
 - d) prefer not to answer

THANK YOU FOR YOUR TIME AND HELP WITH ANSWERING THESE QUESTIONS!

Appendix 5: General norms for soils**Table 1: General norms for soils** (Source: Raath, Dr. P., personal email communication, 2013).

ANALYSIS	MEASUREMENT UNITS	OTHER CRITERIA	MEASURED VALUES			PROBLEM ASSOCIATED WITH	
			LOW	ACCEPTABLE	EXCESSIVE	LOW VALUE	EXCESSIVE VALLUE
pH		Measured in water (H ₂ O)	< 6.5	6.5 - 7.5	> 7.3	Poor growth, impeded fine root development, reduced P availability	Low availability of nutrients
		Measured in Potassium chloride (KCl)	< 5.5	5.5 - 6.5	> 8.3	Poor growth, impeded fine root development, reduced P availability	Low availability of nutrients
Organic carbon	Percentage (%)		< 0.5	0.8 - 1.5	> 1.5	Soil compaction occurs easily	Excessive vigour, high costs to maintain
Electrical conductivity (EC)	mS/cm			1.0 - 2.5	> 4		High salt concentration
Resistance	Ohm (Ω)		< 100	> 400		Unsuitable for crops; salinity levels too high	
Phosphorous (P)	mg/kg (ppm)	Soil with clay content 0 - 6 % (sandy)	< 20		>150	Phosphor requirement	Decreased Zn-uptake
		Soil with clay content 6-15 % (loamy)	< 25		>170	Phosphor requirement	Decreased Zn-uptake
		Soil with clay content > 15% (clay)	< 30		>200	Phosphor requirement	Decreased Zn-uptake
Phosphorous (P₂O₅)	mg/kg (ppm)	Soil with clay content 0 - 6 % (sandy)	< 47			Phosphor requirement	Decreased Zn-uptake

Potassium (K⁺) in soil solution	mg/kg (ppm)	Soil with clay content 6-15 % (loamy)	< 58			Phosphor requirement	Decreased Zn-uptake
		Soil with clay content > 15% (clay)	< 70			Phosphor requirement	Decreased Zn-uptake
Potassium (K⁺) in soil solution	mg/kg (ppm)	Ca ²⁺ > 5 cmol(+)/kg, Resistance < 500 Ω, pH (KCl) > 6 or < 5 % clay	< 70	70 - 120		Potassium requirement	Decreased Mg uptake
Potassium (K₂O) in soil solution	mg/kg (ppm)	Ca ²⁺ > 5 cmol(+)/kg, Resistance < 500 Ω, pH (KCl) > 6 or < 5 % clay	< 85	85 - 145		Potassium requirement	Decreased Mg uptake
Exchangeable Potassium (K⁺)	% of Cation Exchange Capacity (CEC)	Ca ²⁺ < 5 cmol(+)/kg, Resistance < 500 Ω, pH (KCl) < 6 and where > 5 % clay	< 4	4 - 6		Potassium requirement	Decreased Mg uptake
Exchangeable Calcium (Ca²⁺)	cmol/kg	pH < 5.5 and < 5 % clay	<2.00	2.00-6.00	>6.00	Potential Ca deficiency	Potential salinity
Exchangeable Magnesium (Mg²⁺)	cmol/kg	< 5 % clay	<0.5	0.50-2.00	>2.00	Potential Mg deficiency	Potential salinity
Exchangeable Calcium (Ca²⁺)	% of Cation Exchange Capacity (CEC)	pH < 5.5 and > 5 % clay	< 60	65 - 85		Lime requirement	
Exchangeable Magnesium (Mg²⁺)	% of Cation Exchange Capacity (CEC)	pH < 5.5 and > 5 % clay	< 15	15 - 20	>20	Magnesium requirement	Soil structural problems/compaction
Exchangeable Sodium (Na⁺)	% of Cation Exchange			< 10	>15		Soil structural problems/compaction

Exchangeable Sodium Percentage (ESP)*	Capacity (CEC)						
		Resistance < 300 Ω			> 15	Gypsum requirement	
Exchangeable Sodium Percentage (ESP)*		Well drained soil, pH(KCl) > 6.5, free lime present			< 15	Fresh irrigation water will leach salinity	
Exchangeable Sodium (Na⁺)		Sand			>0.6		
		Sandy Loam			>1.2		
		Loam			>1.5		
		Silt Loam			>3.15		
Calcium : Magnesium ratio		pH(KCl) < 5.5	< 5 : 1	4 : 1	> 5 : 1	Apply dolomitic lime	Apply Calcitic lime
Nitrogen (NH₄⁺-N and NO₃⁻-N) **	mg/kg (ppm)	Soil analysis results not useful					
Chloride (Cl⁻)	mg/kg (ppm)			< 350	> 550		Cl toxicity, possible salinity
TRACE ELEMENTS ***							
Zinc (Zn)	mg/kg (ppm)	pH > 6.5	< 1.0			Zn deficiency	
Boron (B)	mg/kg (ppm)		< 0.5	1 - 3	> 3.8	B deficiency; foliar application	B toxicity; lime application
Manganese (Mn)	mg/kg (ppm)	pH(KCl) > 5.5	< 5	5 - 60	> 200	Mn deficiencies; foliar application	Potential Mn toxicity
	mg/kg (ppm)	pH(KCl) < 5.5	< 5	5 - 60	> 60		Mn toxicity, lime application

Swawel (S)	mg/kg (ppm)	If soil C > 0.8%, no S required. S in irrigation water & fertilisers.	<20	20-200	>200	S deficiency	
Copper (Cu)	mg/kg (ppm)		< 5	5 - 25	>25	Copper deficiency possible	Earthworm activity affected

NOTES

*

Exchangeable Sodium percentage (ESP):

This value is expressed as a percentage of the sum of the total basic cations ($\text{Ca}^{2+} + \text{Mg}^{2+} + \text{K}^{+} + \text{Na}^{+}$), or S-value, and gives an indication of the type of salinity in the soil.

ESP > 15 % and resistance < 300 Ω = Sodium brackish soil (ameliorated by the application of Gypsum)

ESP < 15 % and free lime present = Salt brackish soil (ameliorated by using fresh irrigation water)

ESP > 15 % and free lime present = Salt sodium brackish soil (ameliorated by using fresh irrigation water)

**** Nitrogen (N):**

The extraction methods used for determination of nitrogen in soil do not give an indication of the plant available nitrogen for the plant. Vigour norms are used for nitrogen fertilizer applications.

***** Trace elements**

Trace elements are required in very small amounts by the vine and therefore the best method of application is by foliar sprays.

Foliar sprays are recommended only when deficiency symptoms are seen. Toxicity symptoms are normally only alleviated by the application of lime to increase soil pH.

Appendix 6**SUMMARY OF INTERVIEWS CONDUCTED FOR THIS RESEARCH****Table 1: Summary of time spent on interviews in research**

INTERVIEW TYPE	NUMBER OF INTERVIEWEES	DURATION OF EACH INTERVIEW	TOTAL TIME FOR INTERVIEWS	TRANSLATION NEEDED
food waste collection participants	11	20 mins (approx.)	220 mins	yes
"George" – vegetable grower at Polla Park	1	30 mins	30 mins	no

Appendix 7

SELF REFLECTION

The research process ensured that adequate but not excessive focus was placed on the rigidity of methodology and the need for objectivity. Given the interactive nature of the research, interactions with Enkanini residents resulted in a mix of psychosocial relationships developing, which made it difficult for me as the researcher to be an 'outsider' or 'observer'. It is important to recognise that these kinds of relationships have real value and contributed meaningfully to the direction and development of the research itself. Indeed, these interactions allowed me to place a greater focus on the research process and nuances within the settlement that may have otherwise have been missed if I had followed inflexible, linear research methodology and methods. These kinds of strict methods can act like a 'strait-jacket' and tend to isolate the researcher from the research topic. This research also avoids arriving at a point where methods are defended so strongly that the substance of the story is lost (Janesick, 1994; in Chamberlain, 2000).

Meeting with individuals who run different kinds of composting or urban food gardening projects in Stellenbosch and Cape Town shaped and enriched my overall learning process, and especially helped to direct my curiosity at the beginning of the research journey. These interactions, although not formally captured or documented in this thesis, contributed to the overall framing of the research approach itself as well as to my attitude and investigation strategies used at different points along the research journey.

Furthermore, I was able to develop and build on a very useful relationship with the Solid Waste Manager at the Stellenbosch Municipality, Mr Saliem Haider. I first met Saliem in 2012 when I was working on a group project investigating aspects of waste in Enkanini in a course module for Ecological Design at the Sustainability Institute. I found Saliem's willingness to engage with students and also to be determined about making changes in the Stellenbosch Municipality to be remarkable. He is an impressive leader. Saliem was a source of inspiration and encouragement (as well as a useful example for how to handle challenging work environments) during my research in 2013. I interacted with Saliem on a number of occasions, including open meetings at the municipality discussing waste and projects for making the municipality 'greener'. I also met with him individually to discuss budgetary implications of the Bokashi project for its continuation beyond my thesis work. In addition, I met with Saliem, Vanessa von der Heyde (from the pilot project of 2012), one of the Transitions Collective's co-researchers, Yondela Tyawa (who has been regularly involved with the food waste collections since their inception in Enkanini), as well as one of the municipal Ward Councillors later in the year. In that meeting, options and details regarding scaling-up the food waste collection project at the end of the 2013 research were discussed, as well as possible partnerships that could be useful in order to enable the scaling-up operations. I see Saliem as being a particularly visionary and key contact for ensuring that the food waste collections

can continue in Enkanini and elsewhere into the future. I also feel that Saliem is somebody who could be very helpful for nurturing a positive relationship between Enkanini and the Municipality in years to come. This could especially help to mend the fragile relationship that Enkanini residents have with the Municipality.

During the research process, I struggled with a number of internal conflicts, both between different thought-processes, as well as between real-life activities and the constant need for illustrating or checking their academic relevance. Other concerns I experienced were related to the constant internal battle about how I could resolve my biological and ecological curiosity with my need to openly explain the difficult social and quality of life aspects of the research in the context of the study location. I was further troubled by the preoccupation that I would fall in the shadow of my predecessor, Vanessa von der Heyde, who had initiated the food waste research. I was concerned that I needed to find my own role and direction in order to ensure I became an integral part of the project. In this way, I endeavoured throughout my research journey to remind myself of my biological background and the need to include these aspects in my research. A further consolation to me was that I was reminded of the dependence of the food waste collection project on my coordinating and practical roles at several points in the year.

When I tried to create a table summarising the amount of time and types of interactions which I had had with various members of the community, I realised just how difficult it was to summarise my experiences throughout the year in a few words. For this reason, I decided against putting a 'summary table' in the appendices of interactions (apart from of the actual interviews conducted), as I felt that it would not adequately represent how I had become involved in the community, and how I had come to be recognised in the area, as well as how I had managed to develop relationships and friendships with participants and co-researchers.

When I reached the 'end point' of my research, I began to reflect on the impact which my interactions have had on me on a personal and individual level. I remember feeling anxious and nervous about how to begin interacting with co-researchers at the beginning of the year, as well as being very unsteady about which steps to take first with the food waste collections and composting. Looking back, I can see that there was a point in my work where I decided to be less 'organised and in control', and rather to let the spontaneity and creativity in situations and interactions emerge from my work and from the community itself. This allowed me to adapt and be flexible to the informality of the settlement, and to be aware of the exciting interactions which this involved. When I decreased the amount of control I had (by relying on others), I was able to feel the real possibility and momentum of my work. This impact became especially clear to me when I combined my work with that of other researchers. This was an encouragement to me, and combined with the

friendships and welcome acceptance which the co-researchers showed me, I began to feel real growth and progress on both an academic and on a social level as well.

I was particularly encouraged when I realised that I was instrumental in facilitating the process of recruiting and providing employment to a new co-researcher (who was also a food waste collection participant). This was one of the most tangible and 'real life' impacts which I was able to see, in which I had been both directly involved, and which occurred because of the relationships I had developed while running the food waste collections.

In addition, by having ongoing conversations with co-researchers from Enkanini, as well as through listening to the stories of other Collective researchers, I was able to challenge my pre-conceived perceptions of poverty. This enabled me to gather, take stock of and confront my underlying values, ideals, perceptions and opinions on South African government, service delivery, community enterprises and life in informal settlements in the country.

Appendix 8

SUGGESTED PHASED PLANNING FOR ONGOING FOOD WASTE COLLECTIONS

Stage 1:

- Carrying out awareness and education of residents in Enkanini (and possibly Kayamandi) about food waste collections and composting activities;
- Undertaking feasibility studies in selected settlements to determine the acceptability of the collections and composting or recycling by residents;
- Locating and selecting potential sites for gardens and biodigestors in the area (where applicable);
- Training of selected individuals from Enkanini (and Kayamandi) on the production of Bokashi EM and BSF larvae with technology partners.

Stage 2:

- Increasing collections in Enkanini, opening up two more collection points for the waste (strategically located, e.g. close to water points or popular meeting areas);
- Beginning collections in Kayamandi (with two corresponding and appropriate collection points there as well);
- Beginning collections in selected higher income suburbs in Stellenbosch, with motorised transport of food waste in trucks to a collection point in the Plankenbrug industrial area adjacent to Enkanini (charging a service fee to cover the transport, labour and material costs, and which can be used to supplement any costs of processing or collections in lower income areas).

Stage 3:

- Beginning production of Bokashi EM and BSF larvae in a suitably hygienic and secured area in the Plankenbrug industrial area, or at the current Stellenbosch landfill site;
- Expanding collections to possibly 500 households in each area, and doubling the number of collection points; and
- Establishing food waste collection hubs and composting centres – one hub in each settlement.

To summarise, the main management challenges which might be faced when attempting to extend the food waste collection project in Enkanini and beyond, are considered to be as follows:

1. The collection of food waste from households that are geographically spread out requires an organised and co-ordinated means of collecting waste (e.g. vehicles where possible, or bicycles and carts where paths are too narrow, and finally foot transport, where paths are very narrow or difficult).

2. The costs of principal inputs such as the Bokashi EM will need to be reduced. This can be done by training and employing staff (or households themselves) to produce their own Bokashi EM mixes.
3. The use of a central collection hub is critical to streamlining waste collections and other communal activities in densely populated areas with difficult road access.