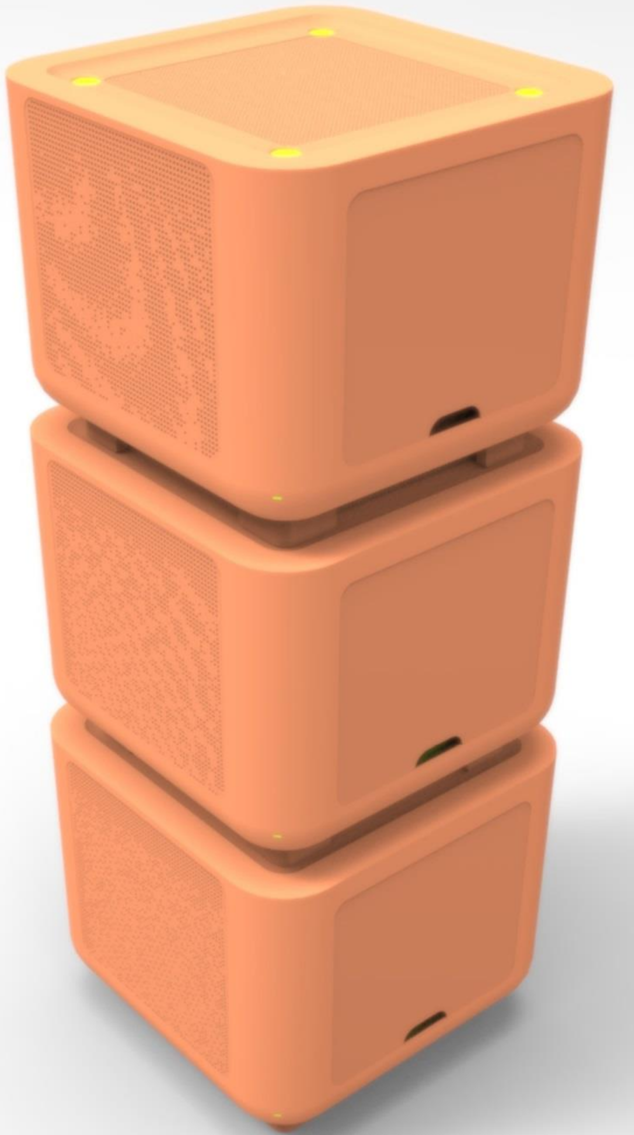

# Mini-Dissertation Research Document

The design of an off-grid food storage system for small-scale urban farmers within the community of Soweto, South Africa


Natalia Tofas

BTech Industrial Design 2014

University of Johannesburg

Supervisor: Angus D. Campbell

UNIVERSITY OF JOHANNESBURG

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## ABSTRACT

This document reports on the design of an off-grid food storage system for small-scale urban farmers in Soweto, Gauteng, South Africa. Central to the study, are the participants, who have informed the solution through a process of co-design, involving iterative prototyping and product development. The project is a response to the observation that there is a lack of an existing design solution for the problem of inefficient post-harvest food storage for small-scale farmers, resulting in post-harvest losses and limited productivity. The study takes a stance that a pragmatic 'bottom up' approach to design will result in a product that is more appropriate for the intended context. Such an approach has more potential to assist the farmers to emerge within their community, and is demonstrated in the resulting design of the *Umlimi Urban* food storage unit.

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# 1 INTRODUCTION

## 1.1 INTRODUCTION TO THE STUDY

Food insecurity is an issue that continues to be apparent in many marginalised communities both in the context of South Africa and other developing countries. Issues of food insecurity are linked to food accessibility, distribution and nutritive value (Shisanya & Hendriks 2011:511). In South Africa, considerations towards this pertinent issue have been approached in the form of government grants and external aid programmes only to name a few, yet food insecurity continues to intensify (McLachlan & Thorne 2009:4). External aid proves to be unsuccessful in introducing technology to marginalised communities as it fails to consider important aspects of the context, rendering the users dependent on the external source. An effective approach to this problem, that remains largely untapped, resides in the field of industrial design, specifically with the use of co-design methods. This research inquiry will, therefore, concern itself with the application of current and emerging theories around Participatory Action Research (PAR), to inform the development of food storage technology to be used by small-scale urban farmers located in Soweto, Gauteng, South Africa.

Research indicates that the concept of small-scale urban farming is ideally positioned within a community to elicit change in food accessibility, distribution and quality, but productivity on these farms is somewhat underdeveloped (Shisanya & Hendriks 2011:510). Small-scale farms that engage in local economic activity, involve a significant amount of preparation, maintenance and financial investment in the farming process up until harvesting. Post-harvest losses and other inefficient post harvesting activities do not do justice to the intense pre-harvesting investments (tilling, purchasing seed, planting, watering and maintaining). This research will respond specifically to the shortfall in productivity that happens during the post-harvest phase, and aim to develop technology that assists. This short fall involves the poor link between harvested produce and points of sale. This problem has been identified to hinder a farm's growth to its full potential. The short term storage will, thus, aim to facilitate the climate controlled transport of produce to points of sale with the prospect of growth to a farm's full potential.

The design criteria, rather than being pre-determined, will be informed through participation with the farmers and so a pragmatic 'bottom-up' approach is taken. The sample group consists of members of the Region D Farmers' Forum (RDFF). This is where the Participatory Action Research, hereafter referred to as PAR, has been conducted. This chapter will contextualise the current agricultural situation within South Africa which will lead to the motivation and significance of the study. A problem statement and research question will lead to the aims and objectives of this study.

## 1.2 THE STUDY

### 1.2.1 CONTEXTUALISATION

The current focus of developing agriculture in South Africa is tailored for large-scale, commercial farmers (McLachlan & Thorne 2009:13). The government has promised to create employment through the development of agriculture, through a focus predominantly on the increase in production and land reform (Cloete, Lenka, Marais, Venter 2009:12). This trajectory does not address the issue of economic activity that occurs in marginalised urban areas such as Soweto. As the contribution to the economy from agriculture and agriculture related activities it is delocalised, only the major urban centres as well as multi-national corporations benefit economically (McLachlan & Thorne 2009:15). Thus, the members of marginalised, less developed urban communities are disconnected from current agriculture economic activity. This is intensified by the fact that the few large-scale farms are ever expanding, disabling small-scale emerging farmers. As a result, marginalised communities are unfavourably inserted into the economy (McLachlan & Thorne 2009:14). The majority of the community members spend their money buying food at local retailers, only for this money to be transferred to the major urban centre, where the food was initially purchased by the retailer (McLachlan & Thorne 2009:13). This explains the existing, highly concentrated, yet geographically dispersed, food retail environment in South Africa.

If small-scale urban farmers have the potential to elicit change in the food system, then post-harvest poor productivity is an important area for design intervention. Selling their harvest is limited by their capacity to store produce. A design intervention needs to address their problems such as: limited or no access to electricity, sensitivity of organic produce, limited time and labour resources for harvesting, inefficient packing methods, differing access to transport and differing scales of farms (McLachlan & Thorne 2009:18). A common finding of this research venture is that every location has potential to physically expand and thus sell more and further establish themselves. Without efficient storage solutions, small-scale urban farmers cannot optimally use their land. (Shisanya & Hendriks 2011:522). Through this realisation, stems the concept of an appropriate food storage technology. Much can be known through the data analysis, but it is crucial that only through participatory research, can the criterion of the design emerge.

Organic food has storage requirements, which are not satisfied by any one product that is available to these farmers. Current low-cost refrigerators that are available to only a fraction of this sample, do not accommodate the transportation and differing volumes of produce from these small-scale urban farms. These refrigerators, furthermore, require disposable electrical energy to which these farmers do not have access to. The identified gap can be described as harnessing the advantages of modern technology and materiality, and combining them with the traditional off-grid cooling method known as evaporative cooling. This method will be further explored in the literature review.

It must be noted that two issues have been raised within the context of marginalised urban areas; a specific issue of poor productivity on small-scale farms and a general issue of poor economic stimulation, food accessibility, distribution and quality. By focusing this design response on the issue of productivity, a greater, more systematic problem area can be indirectly addressed. Thus the design will be informed by the larger context and motivated by the opportunities of small-scale farming as opposed to commercial farming.

### 1.2.2 MOTIVATION

Through analysing the current South African agriculture model, its imbalance has become clear. The current trajectory of the government and other 'top-down' aid schemes struggle to aid in empowering small-scale emergent farmers and local economic stimulation. This project is motivated by the theory of participatory design methods. A truly sustainable solution can only be conceived through understanding the problems at grassroots. Any other remote approach is inadequate if the goal is to empower the user. As the product will be developed in a South African context, informed by the users, the emergent result will most likely offer the opportunity for a novel solution much more closely aligned with existing realities.

The imbalance in the current agricultural model is evident in a concentrated, commercial production of food goods being distributed to the majority of South Africa (McLachlan & Thorne 2009:6). Although the study will be focused on developing a product that emerging farmers in Soweto can use to empower themselves, the interest of this study stems from challenging this distorted food model. As it is unrealistic for this study to revolutionise the current food system, the dissertation and product will serve as a contribution to a more equitable system. Promoting local economic activity will develop communities from within whilst preventing their money from being repatriated away to major urban centres. An additional motivation of this study includes the prospect of creating an incentive for others to prompt similar ventures. Increasing a farm's income could provide incentives and a market for increased production (Shisanya & Hendriks 2011:522).

### 1.2.4 PROBLEM STATEMENT AND RESEARCH QUESTIONS

Although the tangential issues of economic activity and food distribution, accessibility and quality will inform the design, the central research problem is dedicated to the issue of post-harvest productivity on small-scale urban farms. The poor link between harvested produce and points of sale is due to a lack of means to effectively facilitate the transportation and climate control of produce. This inhibits the farmer and farm to grow to their full potential.

The central research question is then, **"how can the design and development of an off-grid, short term food storage solution help to empower small-scale urban farmers to be more productive?"**

### 1.2.3 AIMS AND OBJECTIVES

It is critical to note that small-scale farm storage needs to be customised differently to commercial produce storage as post-harvest activities and resources differ greatly. The above mentioned issues warrant this research response that aims to tackle appropriate post-harvest food storage, a lack of which only intensifies the struggle for farmers to emerge.

As the solution cannot be deduced from faults of a precedent product, success will rely on the progressive realisation of the problem ecosystem. This will result in the solution being closely aligned with the context and identified needs. The aim of this research intervention is to effectively facilitate the transport of produce to points of purchase with the prospect of growth to the farms' full potential. Through a process of PAR the intervention aims to satisfy the requirements of Participatory Technology Development (PTD) and Sustainable intensification (SI).

It is crucial that the design be sustainable within the community. This means that the product needs to be contextually relevant, growing and maintaining the economy and skills within the region. These operations include manufacture, distribution, accessibility, use and maintenance.

# 2 LITERATURE REVIEW

## CHAPTER 2 – LITERATURE REVIEW

### 2.1 SMALL SCALE URBAN FARMING IN SOUTH AFRICA

Small-scale urban farming is noted to have the potential to better distribute organic food that is more nutritive. Local food production is a way to promote more healthy sustainable livelihoods (McLachlan & Thorne 2009:9).

Promoting this ecological challenge through a lens of food security could bring much needed employment to marginalised urban communities. It is necessary to not only promote current small-scale farmers but to encourage others to farm since South Africa's potential to feed itself still remains largely untapped (McLachlan & Thorne 2009:11). Although only 3% of poor households in Johannesburg engage in farming activities, 31% are totally dependent on what they produce (McLachlan & Thorne 2009:11).

Cloete *et al* state that small-scale agriculture has the ability to absorb many people with limited skills, and as farms develop, the new skills learnt by farmers are valuable (2009:11). There is an emphasised need for food insecurity to be addressed through increasing efficiency in production and exploiting competitive advantages (2001: 12).

Small-scale farmers can range from subsistence to commercial depending mostly on land and labour resources. They have access to local supply chains but often fall short in transporting sufficient stock to points of sale (McLachlan, Thorne 2009:18). In the study by Cloete *et al* (2009:20), 40% of the farmers sold their produce in addition to using the produce for their own household consumption. The remaining 60% of farmers were subsistence farmers. There is an indication that the longer the period of involvement with urban farming activities, the more established a farm becomes (Cloete *et al* 2009:45). Land ownership does not seem to be a prerequisite for production as production leading to income often takes place on communal land (Cloete *et al* 2009:45).

Much of the post-harvest loss of fruits and vegetables in developing countries is due to the lack of proper storage facilities. While refrigerated cool stores are useful commercial methods of preserving produce, they are expensive to buy and run. Freezing also changes the texture of produce and could reduce their nutritive value (Indian Agricultural Research Institute [sa]: 1). Furthermore, current refrigeration consumes electricity, which is not always available on farm sites, and does not facilitate the proper storage of produce from a farm site to various points of sale. The moment food is harvested from its source it, naturally, begins to spoil. The longer it is left without appropriate storage, the more it loses in appearance and nutrients (Nummer 2002: [*sp*]). Consequently, in developing countries there is an interest in simple low-cost alternatives, such as evaporative cooling which is simple and does not require any external power (Indian Agricultural Research Institute [sa]: 2).

The project will be motivated by Brian Nummer (2002: [*sp*]), who promotes reconnecting with traditional methods to create roots in local lands, developing already formed communities and the livelihoods of its people.

## 2.2 PRECEDENT STUDY

### 2.2.1 SHORT TERM STORAGE

Post-harvest produce losses commonly occur from warmer temperatures leading to the moisture loss of produce (Bhatia 2012:1). Short term storage of produce is aimed at maintaining its appearance and nutritive value, and thus its success at points of sale. This is achieved with correct temperature, humidity and airflow (Bhatia 2012:1). A precedent method of storage, namely evaporative cooling, can achieve these criteria and will be used as an aspect for the design intervention (Bhatia 2012:1). Evaporative cooling is the precedent method being explored as it fits the criteria of off-grid, low-cost methods that assist the short term preservation of organic perishable fruits and vegetables. Evaporative cooling is a long known principal of cooling, originally developed by Egyptians (Elkheir 2004:[*sp]*). The principal was then first applied to food storage in Nigeria in the form of a Zeer Pot (figure 1) (Elkheir 2004:[*sp]*).

The basic principle of this method relies on cooling by evaporation. In order for water to evaporate, it draws heat energy from its surroundings which results in a considerable cooling effect. Evaporative cooling occurs when warm, dry air (having a low relative humidity) passes through a wet surface. At this point, evaporation occurs by use of the heat energy and thus the surrounding area achieves a lower air temperature and increased humidity. Intensity of cooling and humidifying is directly proportional to the rate of evaporation. The humidity of the surrounding air affects the efficiency of the evaporative cooler. Ideally surrounding air should have a low relative humidity as saturated air will inhibit the cooling process. (Indian Agricultural Research Institute [sa]: 2).

> Evaporative cooling will always follow the laws of nature, so when hot and dry conditions exist, the properly designed and maintained evaporative system will always perform cooling, as sure as a thrown rock will fall to the ground (Palmer 2002:2).

There are many different design approaches to evaporative coolers. The design will depend on available materials and the farmers' requirements. Relevant examples of evaporative cooling designs are described below.

Figure 1: Zeer Pot. Brown, J. 2010.

Figure 2: Larder. Phillips Design. 2011.

Figure 3: OLTU. Fabio Molinas. 2013.

## 2.2.2 PRECEDENT TECHNOLOGIES

In order to develop a new short term storage product for small-scale urban farmers, an exploration of different design approaches to this technology will assist in incorporating the most appropriate cooling aspect into the design. The principal of evaporative cooling has been observed in its most basic form and applications of this basic principle can be identified in a vast array of fields. The following precedent examples are specific to the realm of industrial design in an effort to store food. These designed products use the advantages of evaporative cooling as a core principal, but fulfil a greater, more specific function, the systems have been appropriately designed for use in their respective contexts.

A current trend in more developed countries is the transfer of this basic evaporative cooling technology from its place of origin, Africa, without an appreciation of the technologies original context. The Larder, designed by Phillips (figure 2), aims to revive the African design in a domestic, contemporary kitchen. Using twin-walled terra-cotta evaporative cooling, similar to the Zeer Pot, the compartments vary in wall thicknesses and volumes and are designed to keep different types of food at different optimal temperatures (Van Heerden 2011: [*sp*]). The Microbial Home, a range of products to which the Larder (figure 2) belongs, is a proposal for an integrated cyclical ecosystem where each function's output is another's input. In this project the home has been viewed as a biological machine to filter, process and recycle what one conventionally thinks of as waste.

The OLTU (figure 3), storage system is an alternative replacement of electrical refrigeration. The design uses clay containers for optimal food storage of different produce. It is intended to be used, coupled with the traditional active refrigerator that is common in developed households. Both the Larder and the OLTU food storage systems are designed for domestic use, motivated by rethinking home consumption of energy and release of pollution (van Heerden 2011:*[sp]*).

Each of the designs shown are successful in their respective contexts and for their intended users. This design intervention is warranted by the lack of a thoroughly considered design approach, using evaporative cooling, for small-scale urban farmers in the context of Soweto. As the transfer and optimisation of this basic technology has been designed to benefit users so removed from the origin of the technology, this research intervention aims to revive the technology in a region closer to its origin by designing for a South African specific user group.

## 2.3 LITERATURE REVIEW ON RELEVANT THEORIES

### 2.3.1 PARTICIPATORY DESIGN AND PARTICIPATORY TECHNOLOGY DEVELOPMENT (PTD)

The seminal text, 'Participatory Design with Marginalised People in Developing Countries' by Sofia Hussain, Elizabeth Sanders and Martin Steinert (2012: 91) provides a general context of challenges and opportunities in this domain of study. The study explains the possibilities of participatory design with the understanding of the different circumstances of developing regions. Hussain *et al* (2012: 91) observe the common use of this theory for economically or socially marginalised people in developing countries. It is also stated in this study that only by including users in the design process, can their needs be truly understood (Hussain *et al* 2012: 91).

Participatory Technology Development (PTD) is more associated with the field of development, however its central tenant is also that of participation, and is a forerunner to the use of participation in design. PTD has a larger history relevant to agricultural development. PTD has been advocated as a way of increasing the likelihood that technologies developed will be suitable for resource-poor households (RPH) (Bellon: 2001).

A traditional interpretation of PTD is explained by Mauricio Bellon (2001:7). His research on farmer participatory research continues a tradition of developing practical, instructive guides that are based on direct experience in field research. Bellon (2001:7) offers a valuable guide including the insights as well as the uncertainties that agricultural scientists have often experienced as they seek to make the research process more inclusive and ultimately more rewarding for all of the participants. The strength of this approach involves foresight of limitations which will help ensure the design of a food storage unit can be adapted accordingly. Farmer participation in agricultural research is a systematic dialogue between farmers and those developing technologies to solve problems related to their context and ultimately increase the impact that PTD can have in the reality of small-scale urban agriculture (Bellon 2001:9). By responding closely to farmers' concerns and conditions, the design intervention of a storage technology is more likely to be adopted widely and respond to important social issues such as sustainability.

Czech Conroy and Alistar Sutherland (2004:1) conclude in their study, 'PTD: Maximising impacts through the use of recommendation domains' that PTD can be cost effective provided that various conditions are satisfied. These conditions include: PTD should be based on an effective diagnosis and research site selection, Research Domains (RDs) should be identified, information about the technology should be available to the users in the RD, and required resources should be made available to disseminate the technology to the individuals in the RD (Conroy & Sutherland 2004:1).

In a paper by Andy Dearden and Haider Rizvi (2008:2) they examine the role of participatory approaches to design of interactive systems. Within interactive systems design, there is an established tradition of user participation and a set of methods associated with this tradition (Dearden & Rizvi 2008:2). Other than concurring with previous authors explored in this literature review, Dearden and Rizvi also highlight the importance of constant vigilance and critical reflection on one's goals and practice. This will be expressed in the design response via several prototype iterations, refined with input by the farmers, and critical reflection throughout the development.

Authors Belinda Tynan, Cherry Stewart, Rachael Adlington and Mike Littledyke (2008:1056) emphasise the importance of who leads a participatory research project in relation to the development of, in this case, the design of a product. The focus of who leads overlaps the domain of PAR, which is why it forms the greater methodology of this research intervention. Tynan *et al* conclude with the significance of engaging with participants in order to develop technology as a form of empowerment (2008:56).

In the case of resource-poor households there is a large factor of diversity among farming methods, depending on available resources of time, land, tools and labour. It has, thus, been realised that the solution will have to cater for this heterogeneity (Bellon 2001:9). Furthermore, long term sustainability is a crucial factor to be considered in designing for marginalised communities. Because of the nature of this research project, having resource and time limitations, the implementation strategy will have to be self-sustaining. In order for the solution to be considered as truly participatory, the benefits of the product must be able to sustain themselves in the community without external dependence (Brand & Campbell 2014: 5). This will be considered in the form of design, manufacture, distribution and maintenance. This approach positions this research response alternatively to traditional aid ventures, and assures its alignment with the current and emerging theories. These, above mentioned, factors will be addressed in the design response to help ensure the probability of a large number of small-scale farmers adopting the technology (Bellon 2001:1). The identified requirement of sustainability, in this notion of thinking, gives reason to a sub-dominant theory in this literature review, namely, Sustainable Intensification (SI).

### 2.3.2 SUSTAINABLE INTENSIFICATION (SI)

The definition of sustainability, that is most relevant to this context, is that of sustainable development. Sustainable development is essentially described as the capacity to meet the current needs of society and the environment without compromising the abilities of future generations and allowing those generations to meet their own needs (El-Halwagi 2012:1). It is understood that sustainability is achieved when the use of resources is maintained or improved to benefit the social and environmental conditions over time. Thus, it must be achieved without exceeding the environmental capabilities that support the system (El-Halwagi 2012:1). A growing interest in sustainability can be attributed to the increase of industrialisation, the depletion of natural resources, global climatic change and risks to biodiversity and various ecosystems. Successful sustainable systems achieve the three principle objectives of societal equality, environmental protection, and economic growth (El-Halwagi 2012:1). This concept is commonly and respectively known as meeting the triple bottom line of, "People, Planet, Profit".

As societies and environments suffer the consequences of poor design, the demand for alternative solutions in turn becomes increasingly important. Authors McLachlan and Thorne (2009:12) propose that all new approaches to food production and access must consider marketing, transportation, consumption and waste aspects of the system.

Sustainable Intensification (SI) is a term becoming increasingly relevant in discussions around the future of agriculture and food security. The term was created in the context of similar urban agriculture ventures; where productivity is inefficient as a result of inefficient farming operations. This theory highlights the ideals of what should be achieved in small-scale urban agriculture as opposed to existing, commercial production systems (Montpellier Panel Report 2013:4).

# 3 METHODOLOGY

## 3.1 RESEARCH PARADIGM

A large portion of this research will be informed through a qualitative research approach, reliant on the meaning and opinion of informants. It is critical that the design emerges from the true needs and context of the participants (Kupin, Levinson & Reeves 2008: 401). Their inclusion will affect the design through the adoption of PAR. Unpredictable data will result from many data gathering methods such as interviews, observations, participatory sketching and model making in the form of farmer focus groups and individual interviews.

The analysis of the product with regards to specific research on storage methods will inevitably be incorporated in desktop research with consideration of qualitative data.

## 3.2 RESEARCH DESIGN

Participatory Action Research (PAR) will guide this research. In the context of exploring, explaining and acting on community issues, Alice McIntyre emphasises the importance of:

> …Co-creating spaces with marginalised groups where they can speak their stories into life; where they are free to choose-authentically or for themselves, individually, and in the context of mutual participation-how to take actions that will improve their current situations (2008:17).

McIntyre (2008:17) further states that the unexpected challenges that emerge during the research, ought not to derail the process, but rather can be used to reconstitute how research is done. PAR creates a means through which participants' awareness can be raised of their individual and collective skills, resources and abilities to influence the inquiry and change the design as it develops (McIntyre 2008:17). PAR has the inherent potential to explain and interpret reality so as to change it.

Despite the wide range of research practices and ideologies attached to PAR, there are underlying doctrines that are specific to the field of PAR: a collective investment to investigate a problem, a self and collective engagement in reflection as the project develops, joint decisions that lead to a useful solution that benefits the participants involved and building an alliance between the researcher and participants in the designing, implementation and dissemination of the process (McIntyre 2008:1).

These aims are achieved through a cyclical process of exploration and action at different stages of the design project.

Fran Baum, Colin MacDougall, and Danielle Smith (2006:3) suggest that PAR differs from most other research designs as it is based on reflection, data collection and action that aims to reduce inequalities through involving the people who, in turn, take actions to improve their own situations.

William Whyte (1991:247) makes a case that PAR is a powerful strategy to advance both science and practice. PAR involves practitioners in the research process from the initial design of the project through data gathering and analysis to final conclusions and actions arising out of the research (Whyte 1991:247).

## 3.3 SAMPLE GROUP

Qualitative research involves the selection of small sample groups that are closely aligned to the research, to ensure that valuable information is gathered (Polkinghorne 2005:140). Informing this study, a sample group of 11 participants was purposefully selected. They are sourced from the Region D Farmer's Forum. Newly emerging, as well as experienced, small-scale farmers are included in the sample group in order to understand the spectrum of needs from different users. This results in a range of participants, both male and female, some of whom are fluent in English and others who require a translator.

## 3.4 DATA COLLECTION AND ANALYSIS

The initial stage of research involved analysis of the over-all problem ecosystem. This was undertaken during visits to small-scale urban farms at varying stages of development as well as attending monthly RDFF meetings. Findings from these visits were documented by means of photographs, voice recordings and written notes. After a series of initial observation, semi-structured interviews were prepared for the participants. These interviews took place in order to discover insights specific to food storage needs with regards to small-scale urban farmers.

Semi-structured interviews were used in order to encourage a natural flow of conversation, questions and responses as suggested by David Diehl, Lisa Guion and Debra Mcdonald (2011:1). Semi-structured interviews allowed the researcher to do a detailed enquiry and allow for critical topics to emerge without presumption (Gray 2004:382).

The use of audio recordings, while engaging with a participant, allows the interviewer to focus on the dynamics of the interview and pilot the structure of it (Kvale 1996:160). Once initial field work data was gathered, all audio recordings of structured and semi-structured interviews were transcribed into written text (Appendices II, III, IV & V). This allowed for a structured means of data analysis (Kvale 1996:163). This analysis was informed by common themes that were categorised in the transcription phase. The abbreviation and categorising of data gathered allowed for a succinct framework that could effectively inform the design brief.

Through analysis of the first interview phase, the initial design criteria could be deduced from the highlighted problems and themes. This allowed for a design exploration phase in the form of sketches and mock ups which acted as a means of engagement and critique for the participants. These successive points of contact were coupled with informal interviews so that preferences of the design direction could emerge and be recorded.

This feedback was used to develop the first prototype which was later tested by the participants. Preferences of the first prototype were used to refine the second prototype which follows the same critique process only to inform the final prototype. The process involved iterative designs in order to incrementally arrive at a more suitable solution.

Interaction and observations with the prototype testing were photographed and responses were recorded in the form of notes, sketches and audio recordings.

## 3.5 ETHICS

Participation of all contributors occurred of their own will, after the project was explained and consent and anonymity was agreed upon (see Appendix I & II). The importance of correctly representing participants' viewpoints is well noted as suggested by Ina Wagner (2012:9). Throughout the process, the participants were informed of progress, and visions of the product. Users were assured that they held their own decision power and were treated as equal contributors to the design (Wagner 2012:14). The participants were sourced from various farm sites. The multiple farmers on each site felt differently about use of their names in this document. Only names of farmers feeling indifferently about the use of their names have been mentioned. So as to not break any agreements of the consent and to refer to all the participants in a structured manner, they have been labelled from P1 to P11.

# 4 DATA ANALYSIS & PARTICIPATORY DESIGN

The desktop research established guidelines for the design direction. Initial field research then took place in the form of participatory, semi-structured interviews and observations. Rather than being a linear process, Participatory design involves iterative prototyping through maintaining a constant dialogue between the designer, the participants and other stakeholders. Throughout the design process, the concept was exposed to real scenarios, this allowed for improvisational change that could not have been predetermined by any other source than that of the products context (Simonsen 2010:18).

Jesper Simonsen (2010:19) stresses the importance of design, use and redesign as it quickly allows one to learn about the possibilities and constraints imposed by the artefact.

> …This involves collective 'reflection-in-action' through the establishment of a process of mutual learning between designers and users from the work domains in question (Simonsen & Hertzum 2010:2).

This chapter will discuss the key findings that were discovered through participation in the field. It will explain how participatory actions informed the design throughout the process. The chapter will be structured as the design process happened, not separately to the key findings but, simultaneously. It will proceed from determining the initial design criteria to refinements in the detailed design process, and all the phases in between.

## 4.1 OBSERVATIONS AND INITIAL INTERVIEWS

Initial observations took place at a basic farmers' workshop held by *Food and Trees for Africa* on 29 April 2014. It allowed gathering of general information around the context of small-scale urban farms in Soweto. Many community small-scale farmers who attended were from the RDFF and were interested in developing their farming skills. These people rely solely on farming for a living. They were mostly pensioners, both male and female and generally over the age of 50. For the purpose of training, Agri Resource Centre, a small-scale farm in Tladi, Soweto, was used for the demonstration. A definite sense of community was observed when a discussion amongst the farmers took place about each other's gardening knowledge and techniques. This farm site was not nearly being used to its full potential, a factor common to all sites visited thereafter.

Connecting with one of the more successful small-scale farmers in Soweto and the chairman of the RDFF, Sakhile Skhosana, not only brought insight to his farm, but enabled access to many other smaller-scale urban farms in Soweto. Mr Skhosana, from now on referred to as P11, and Philasande Cele, here after referred to as P1, have leased the farm on the Siyazenzela site at the Phumzile Primary School on Mabalane Street, in Phiri, Soweto. After observing this site, the potential for its growth became clear as did the struggle for upcoming community farmers. P11 openly spoke of his farm's successes, struggles, available resources, long and short term visions. Participation on this farm site involved key informants (P11, P1, P2 & P3) whose experience brings insight to the context of less developed small-scale urban farmers.

On a less developed site in Phiri, the farmers (P9 & P10) claimed that they were amateurs compared to P11 (2014:42-49), but their garden was none the less impressive. Without any farming background, P9 along with some friends and family members, managed to work their way into a successful garden that occupies the equivalent area of a football field. P10 claims that expanding further is only a matter of time (2014:30-32).

On another small-scale community farm in Tladi, Soweto (Sekakalame Molepo), many farmers tend to their own pieces of land on the site of a school garden (P4, P5, P6, P7 & P8). After the project was explained to these farmers, they were eager to participate. A semi-structured interview procedure was adopted. This involved one main respondent (P4), who had the most experience (6 years), with occasional input from the other farmers. A lot of the land was still unused and needed to be cleared for future used. The researcher's participation provided insight into how the farmers apply the concept of permaculture. It is an advanced way of designing a farm that the farmers share with fellow farmers who are interested. Some of the crops were neglected, resulting in wilting and thus post-harvest losses. This attracted more rats (P4 2014:230-235). Earlier harvesting would help this situation. It became clear how the storage technology, designed appropriately, could be a viable investment for small-scale farmers at different stages of their development.

A topic that was raised at RDFF meetings, the farm sites and identified through desktop research, emphasises the importance of selling produce at markets for small-scale urban farmers within a community. Many of the farmers admitted to having low stock and were advised by the RDFF to increase their produce and prepare stock for the first planned farmers' market. Transportability and all other operations linked to a market scenario thus become important aspects of the design.

Common to most of the farmers at the start of the project was a range of vegetables that included: spinach, spring onions, mustard, chilli, peas and various herbs. As summer became more apparent, the farmers planted summer crops such as tomatoes, brinjals, carrots, onions and potatoes. It was useful to witness the harvesting and in-house purchasing process which involves plucking, cleaning, packing and stacking. The manual harvesting process is time consuming. It was observed that substantial post-harvest preparation is needed before produce is purchased by passers-by or transported to points of sale. Thus, harvesting in advance and short term storage may help a farmer to more efficiently prepare stock for sales.

The first farmers' market took place near Naledi Hall; a pension pay-out location in Soweto, on 2 September 2014 (figure 4). As markets are an important point of purchase, attending the launch of the market provided key observations that informed the product development of the short term food storage design. A common theme here was planning to appeal to customers. Produce was harvested that morning and was generally arranged in a structured manner. The arrangement of produce consumed a substantial amount of time and a successful setup was dependent on available display resources. This involved setting up on whatever containers and surfaces were available to the farmers who had limited time to plan this (figure 5 & 6). The design of the storage product aims to render farmers more independent from the availability of these external resources on the day of a market. During the market, it was observed that customers enjoy shopping and they were interested in buying what looked and smelled the best. In an effort to protect the produce that was drying up from direct sunlight, one of the sellers covered her spinach with black plastic bags (figure 7). With black attracting and absorbing heat this was not as effective as a solution as intended. Other efforts to maintain the longevity of produce involved activities like pouring water directly over produce using a water bottle (figure 8). This method was only partially effective and wasted a lot of water. Another ingenious preservation method was the use of ice directly on the produce, which provided cooling and moisture (figure 9). It was noted that ice is an available resource to some farmers and an optional ice compartment could be included

**Figure 4**: First farmers' market. Tofas, N. 2014.

**Figure 5**: Make-shift setup. Tofas, N. 2014

**Figure 6**:Make-shift setup. Tofas, N. 2014.


Figure 7: Covering produce. Tofas, N. 2014.


Figure 8: Watering produce. Tofas, N. 2014.


Figure 9: Preserving produce with ice. Malan, N. 2014.

into the storage design.

P4 and the rest of the farmers at Sekakalame Molepo, like the farmers at Siyazenzela, expressed that they were unable to harvest all of their produce for the market because of the limited time and labour available on the morning of the market. Currently, preparing by harvesting the day before is out of the question as the produce will not be fresh enough the next day. If the short term storage unit can accommodate for harvesting the day before, farmers can be more efficient in their harvesting and selling and therefore sell more produce and waste less.

## 4.2 PRODUCT DEVELOPMENT VIA PARTICIPATORY SEMI-STRUCTURED INTERVIEWS

### 4.2.1 PARTICIPATORY SEMI-STRUCTURED INTERVIEWS

The conceptual stage of design was informed by initial observations and semi-structured interviews. Participatory interviews then guided the chosen design direction of the off-grid food storage unit. These participatory interviews took place at the Siyazenzela site at Phiri Primary School on 13 August 2014 and 20 August 2014. This involved a total of 4 participants (P1, P2, P3 & P11), three of whom are key informants (P1, P2 & P11). Farmer P11 is the chairman of the RDFF, Farmer P1 is a biotechnologist and P2 has over 10 years of farming experience. The key informants provided valuable insight as to what will work for small-scale farmers at their different stages of development. The first technology design workshop involved design development using rough sketches (figure 10). P1 explained that they have access to a small fridge (2014:88-89) and they use crates (figure 11 & 12) to carry their produce from their site to various points of purchase (2014:290-298). He explained how the crates stack and how he fills them with different produce and the process of carrying the full crates to monthly markets, local

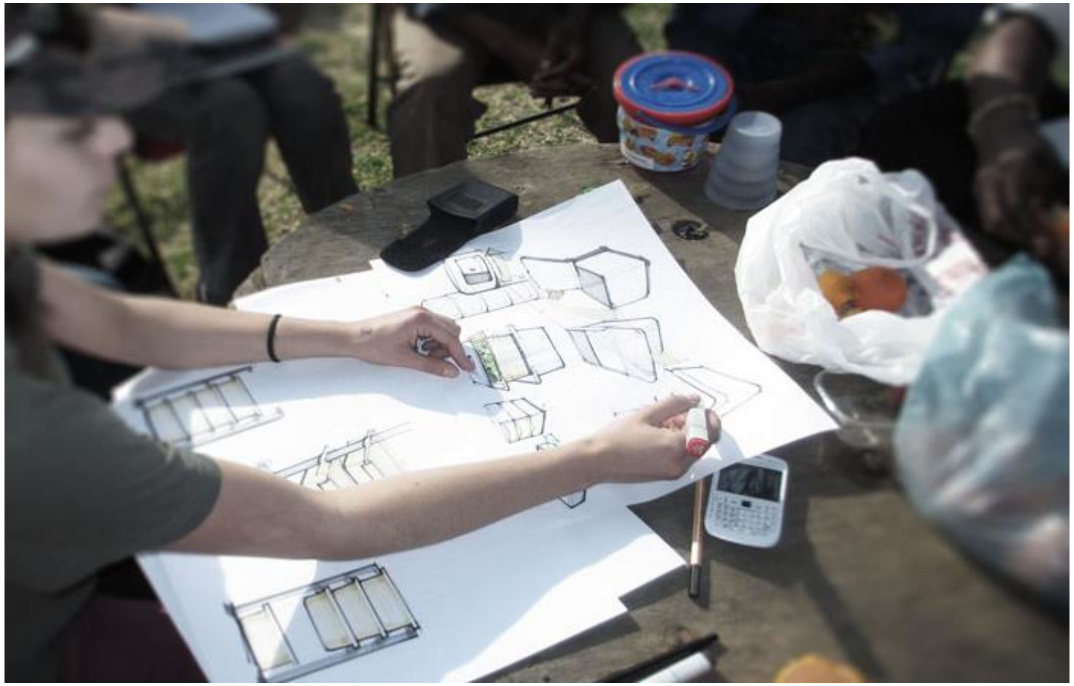


Figure 10: Development using rough sketches. Tofas, N. 2014

Figure 11: Crates. Tofas, N. 2014

Figure 12: Crate. Tofas, N. 2014

vendors, household customers and street-walking customers. Points of difficulty and limitation were highlighted in terms of functionality and user interface; P1 mentioned that an excess of produce becomes a problem because their small fridge has limited space (2014:90-91). He mentioned that approximately 20% of produce is given away to the school and approximately 15% is used for the compost heap because it would otherwise spoil. This excess in produce varies between sites and would otherwise go to waste, but as highlighted by P1, "We do not waste." (2014:21-26). P1 also mentioned difficulty in manually carrying the crates, full of produce, long distances (2014:291-293).

There was interest regarding more storage space in order to accommodate for excess production, to reduce post-harvest losses and allow for an increase in production in the future. This would thus have the potential to increase income and the area of a farmed land, since more land was available, but not utilised due to the lack of bulk storage.

In order to familiarise and engage all of the participants, interactive mediums namely, play-dough and Lego were used to encourage farmer participation whilst communicating some initial ideas. A visual description of what the product could do for the farmers was informally presented (figure 13). Their existing small fridge was roughly modelled by the designer (pink clay on left in figure 13). The toothpick coming out the back symbolises a wire and the use of electricity. The farmers are not willing to pay any excess electricity. Many farmers that were interviewed, buy small amounts of limited electricity at a time, like 'airtime' (P10 2014:81-81). The colourful model on the right is the storage that was proposed, based on the current, familiar stacking system that the farmers use; the units offer an efficient use of space as well as an off-grid cooling system that is transportable. The farmers mentioned that during their last harvest they lost out 'big time' because, while having about 250 bunches


Figure 13: Play-dough and lego modles. Tofas, N.

of spinach in their garden, they were only able to pack 50 into the 'bakkie'. They said they could have made R1000 instead of R250 on the day of the market (P3 2014:210-212).

Transporting produce to markets and other points of purchase is represented by the Lego base with attached wheels. This suggests the farmer can push and pull his/her produce wherever they would like to. There is no wire attached and this suggests that it is off-grid. A rough map of the farm, vending corners and market location were drawn on a piece of paper. It was suggested that the unit could be moved on the roads between these points. The participatory session aimed to uncover problems in packing, transporting and selling activities. P2 highlighted matters such as accessing the food from the storage (packing and selling) and customers' visibility of the produce in the storage unit. Rough sketches were used in order to understand some of the initial concerns of the farmers (figure 14). At this stage, the sketches did not dictate visual forms of the product. They were a successful aid to the dialogue that highlighted matters of user-interface, mechanical advantage, accessibility, visibility (display), durability and cost.

Before participation, it was originally intended for a stationary storage unit to be designed for use by the farmers on their farms. The storage unit would act as a facility to allow for further production, similarly to commercial farms. For true participatory design it was crucial to consider all of the, above mentioned, tangential problems the farmers identified. The initial concept was, thus, transformed into a unit that included; transportability so that the farmers could access their local markets to distribute their produce; modularity so that the farmers could customise the unit according to their varying produce outputs (this versatility could allow all types of small-scale emergent farmers to use the product no matter their stage of development); durability could ensure the sustainability of the unit in the context of use; and

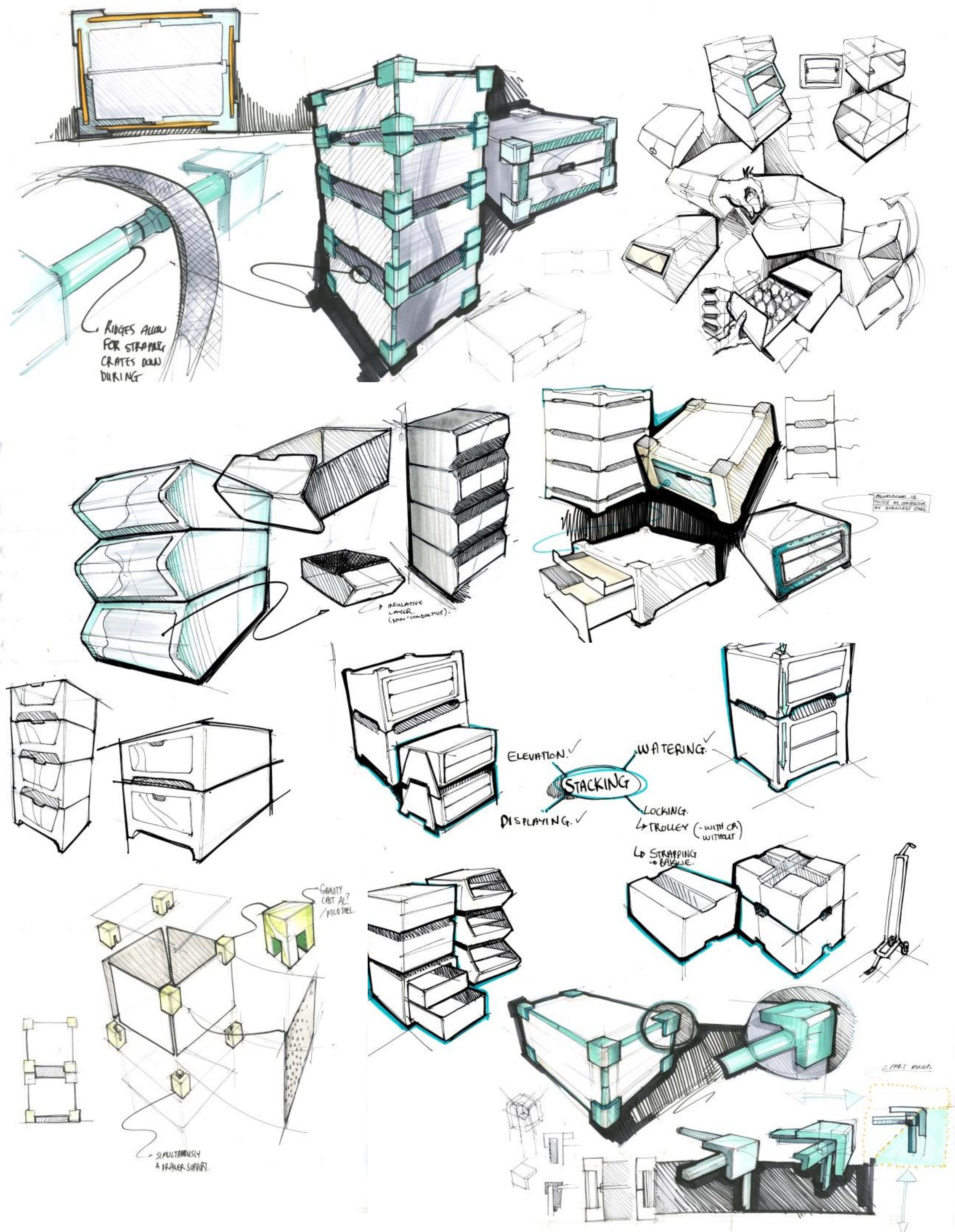



Figure 14: design exploration regarding initial farmer's concerns. Tofas, N. 2014

the unit needed to operate off-the-grid in order for the portability to be possible, as well as to accommodate for the farmers' limited access to electricity. Attending to these factors has resulted in a solution that is more appropriate to the context of use.

The initial participatory dialogue served as an introduction, creating a common project base for the participants and the designer. The playful approach to visual representation assisted the flow of conversation and moved the concept forward whilst establishing its initial criteria.

### 4.2.2 MORE FOCUSED PARTICIPATORY INTERVIEWS AND PRODUCT DEVELOPMENT

After many interviews with similar smaller farmers, the researcher was becoming familiar with the storage needs specific to small-scale farmers as well as the general small-scale farming ecosystem. Fulfilling the specific needs of small-scale urban farmers, the product is focused on short term food preservation. Evaporative cooling is incorporated into a product that addresses the needs of a farmer and his/her actions at points of sale such as markets. This brings into the mix, the consumer, who is concerned with aesthetics (P4 2014:365-372). A farmer's main goal is to sell their produce to make income (P1 2014:203-220). "When I walk with my produce in the streets of Soweto, I wear bright green" (P2 2014:47-49). Aesthetics and displaying food thus becomes an important factor of the design.

Selling scenarios take place in-house and in markets. In-house refers to the activity when customers come to the farm, walking in the streets to target street side customers and nearby houses, or dropping food at a site such as a vendor or a 'spaza' shop (P1 2014:272-276). These activities take place to generate cash flow and help to economically sustain the farm. It is important to consider how storage can facilitate this.

Figure 15: Prototype tests 1,2,3 & 4. Tofas, N. 2014

Figure 16: Prototype Assembly. Tofas, N. 2014

Figure 17: Prototype Assembly. Tofas, N. 2014

The other location for sales is the market. This is an important mass income retail scenario for a farm involving the 'mass' preparation of produce to be displayed and maintained throughout the proceedings of a market day. Produce that is not sold at a market needs to be kept for the following day's sales (P1 2014:22-25). Market sales involve relatively short storage times; such as a maximum of 3 days. The farmers mentioned that harvesting takes place at 3am as they can only sell produce that looks fresh approximately 6 hours after it has been harvested (P1 2014:166-170). For this reason they do not harvest anything leafy or fleshy the day before they sell.

## 4.3 PRODUCT REFINEMENT VIA FIELD TESTING

### 4.3.1 FIRST FIELD TEST

At this point of the project, the researcher was well enough informed to start fabricating the first range of prototypes. Presenting these ideas to the farmers, allowed for their input, it also helped to refine the already established design direction. The initial prototypes tested the principle of evaporative cooling and the possibility of using the traditional Zeer system in an alternative manner. The first roll-out of prototypes, at Siyazenzela on 3 September 2014, mimicked the Zeer system using lighter, more durable materials that will aid with the transportation of the units. Four prototypes were made as an alternatively to the fragile ceramic used in the Zeer, these prototype pots were fabricated from plastic. They were all made to be tested with different water retaining materials placed in between the containers (figure 15,16 & 17). The materials were chosen after a simple test was undertaken to analyse the capillary action of each (ability of a material to absorb moisture in the direction opposite to gravitational force). The materials that were tested had differing capillary and insulation properties. They included: cellulose sponge, felt, 'thinsulate' (synthetic fabric) and soil. Rings on the lids of the pots were colour coded. This helped the testing and recording process in the field. The many holes in the outer containers were an attempt at replicating the porosity of terracotta used in the Zeer, and thus would encourage evaporation (figure 15). The theory is that as moisture is suspended in the walls of the two containers, evaporation will be induced because of the warm temperature of the inner pot. As the heat energy is converted into evaporation, the inner pot is left at a lower temperature. The rate of evaporation is directly proportional to the rate of cooling.

The first iteration of prototypes included six tests in total, four of which mimicked the Zeer. These tests took place at Siyazenzela on 3 September 2014. The fifth test was in a simple container (similar to a lunch box) and the sixth test was conducted with no storage (produce was placed on a tree stump on the farm under the shade). It was important to compare the four main tests to each other to see which material worked best and then compare these results to the two control tests (5 & 6) to see if the technology is actually offering something better than a regular container or no container at all. The lids sealed tightly on the bowls, this was done in order to keep control of the variable factors during testing. Thermometers were placed on the inside of each transparent lid so that temperature could be monitored. Produce (spinage, carrots and spring onion) was placed inside, the lids were closed and the in-between materials were watered. This proved to work well in the field testing. The simplicity of the system indicated that if the product is intuitive, it can be used easily by any farmer. The field test at Siyazenzela ran from 1pm on 3 September 2014 to 12am the next day.

The first prototype roll-out brought some general insight related to resources such as time, labour, water and space. The farmers concluded that the produce contained in the prototypes fared better than the two control tests (5 & 6) although only slightly. The farmers mentioned that, based on the quality of the produce, they would still sell it for the same price the following day. The produce left outside the container was not sellable in the farmers' opinion.

### 4.3.2 CONTROLLED TESTING

The researched believed it was necessary to replicate the testing in a more controlled manner due to the limited success of the field tests. This showed the difference between the four main tests. By running the identical test in a more controlled manner, it was determined that evaporative cooling was happening, but only very slightly. The results were not significant enough to suit the needs of short term vegetable storage. The conclusion of the first prototype roll-out was that; if plastic was going to be used to mimic evaporative cooling as in the Zeer, the system would have to be manipulated to achieve the best results from this alternative material. In consultation with additional desktop research, the factors of the evaporative cooling system were analysed, in order to determine which variables were limiting the cooling. The following key variables were identified: the surface area exposure of the material holding water, the conductivity of the inner pot to allow the evaporation to induce a significant drop in temperature in the area of the inner pot, and insulation from the outer pot and the material holding water.

The tests that were designed to follow, addressed the variable of surface area (tests 7, 8, 9 and 10). Previously, holes were drilled in the outer pot that exposed approximately 30% of the moist material. Altering the prototypes used in tests 1 to 4, the exposed area was increased to approximately 60% by introducing larger cut outs to the outer pot. Testing results improved dramatically showing an approximate further temperature decrease of 8 degrees throughout the four main prototypes. At this stage of testing, it had been confirmed that cooling results were dependent on the daily weather with regards to; temperature, humidity and wind. In the interest of achieving the best cooling results, no matter the surrounding weather conditions, a further test was attempted, in order to test the variable of the conductivity of the inner pot. The original plastic inner pots (used in tests 1,2,3 and 4) were replaced with a significantly more conductive material, aluminium. The results of the tests improved to an extent that was measurable, a reduction of approximately 5 degrees in tests 7, 8, 9 and 10. Desktop research supports the notion that if the inner pot insulates rather than conducts, the cooling process will be hindered.

Once the testing system had been optimised, it was necessary to observe the capillary and insulating properties of the materials between the pots in each prototype. The following observations were made regarding these materials. The synthetic material known as 'thinsulate' proved to insulate well as it maintained the morning's temperature, within the pot, until the warmer afternoon, but it failed to suspend water throughout the walls, not allowing for evaporative cooling to further decrease the inner pot's temperature. Soil, being the original medium used in the Zeer, showed the most impressive cooling results when in optimal weather conditions, but its insulation properties are mediocre. If the pot with soil was exposed to the slightest amount of sun, the soil would conduct this energy to the inner pot and render the evaporative cooling process somewhat redundant. Soil also made the pots heavy for transportation and created a mess when the pots were watered. It was deduced that although this might be ideal for the Zeer system, an alternative would have to be found for this project.

Felt proved to be a sufficient insulator and suspender of water but cellulose sponge was slightly more effective, achieving cooling results very close to those of soil. Cellulose insulated similarly to felt but was able to suspend 0.5 times more water, whereas gravity would affect felt's suspension of water over time.

### 4.3.3 SECOND FIELD TESTING

At this stage of the project, the principle had been refined and the system was clearly understood, the design of the storage unit and all relating aspects were then addressed in more detail. The research now focused more around user interface, functionality and aesthetics. Through the development of many refinement sketches, a product direction was determined (figure 18), incorporating the working cooling system. A full scale visual mock-up was fabricated to resemble the final product in scale and proportion (figure 19). All factors that were addressed through the research were represented in the prototype with sketches to assist the communication of ideas to the farmers. This visual representation of discussions and feedback, raised in previous participatory sessions, served as a platform for dialogue around specific issues of user interface, function and aesthetics. The farmers identified the following as issues for further refinement: a slight increase in scale to accommodate for more produce (specifically upright spinach bunches), the functionality of the drawer and shelf, and elevation from the ground to allow for easy manual transportation. The farmers were satisfied with how the cooling system was designed to be maintained, with the option of using a self-watering method. This method incorporated upside down filled soft drink bottles that drip irrigated the storage units when stacked upon each other (figure 19). In an in-house setting on the farm, the system could be watered manually using a hosepipe, which all interviewed participants had access to.

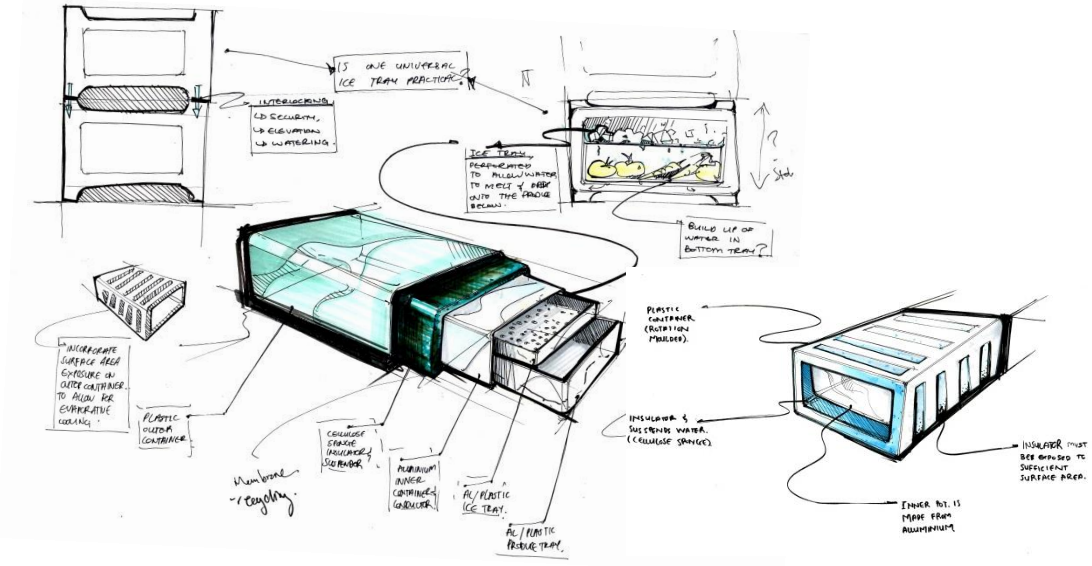



Figure 18: Chosen direction. Tofas, N. 2014.

Figure 19: Second field test. Tofas, N. 2014.

The farmers were satisfied with the simple, yet intuitive, aesthetics of the unit. Progress from this point involved addressing the matters raised by the farmers while maintaining the aspects that they approved of. This was done through detailed design drawings and CAD. At this stage the project was well enough informed for a final prototype to be created.

### 4.3.4 FINAL FIELD TEST AND PRODUCT FINALISATION

The final design was presented to the farmers at Siyazenzela on 29 October 2014. Present farmers included P1, P2, P3 as well some newer farmers. The presentation included a full scale visual model that was near completion (figure 20). All aspects not shown in the model were presented with explanatory CAD renderings (figure 21). All features of the design were highlighted. The farmers' overall impression of the product was positive. P1 was satisfied that his requests were incorporated into the product, namely: a slight increase in scale, elevation from the ground for ease of manual transportation and indents on the perimeter of the top surface that would allow the product to be strapped down while it is transported on a trolley or a 'bakkie'. P1 emphasised the addition of rubber underneath the feet of the unit, to assist its stability during transportation. This was not yet represented in the model or the renders and this addition was noted for the finalisation of the design. P3 was pleased that the model incorporated all the elements mentioned in the participatory design sessions. When asked for his comment, he mentioned that what he saw in front of him was an accurate representation of what he expected based on the co-design process. Alternatively, P2 mentioned that, although he understood the product throughout the process, he only clearly realised the products details that day. This was because CAD renderings and the refined prototype model were a more successful means of communication. The farmers expressed approval of the design aesthetic, stating that it has remained intuitive without any elements of confusion. P2 then continued to appreciate the product similarly to the other farmers. The farmers tested some aspects of the design interface such as manual transportation, stability, accessing the unit and securing the unit down with straps. Other aspects were explained through CAD renderings. In order for a complete testing of the product to happen, the farmers would have to use the product during in-house and market selling. As this project in limited in terms of time, final product testing was limited.

Figure 20: Final field test. Tofas, N. 2014.

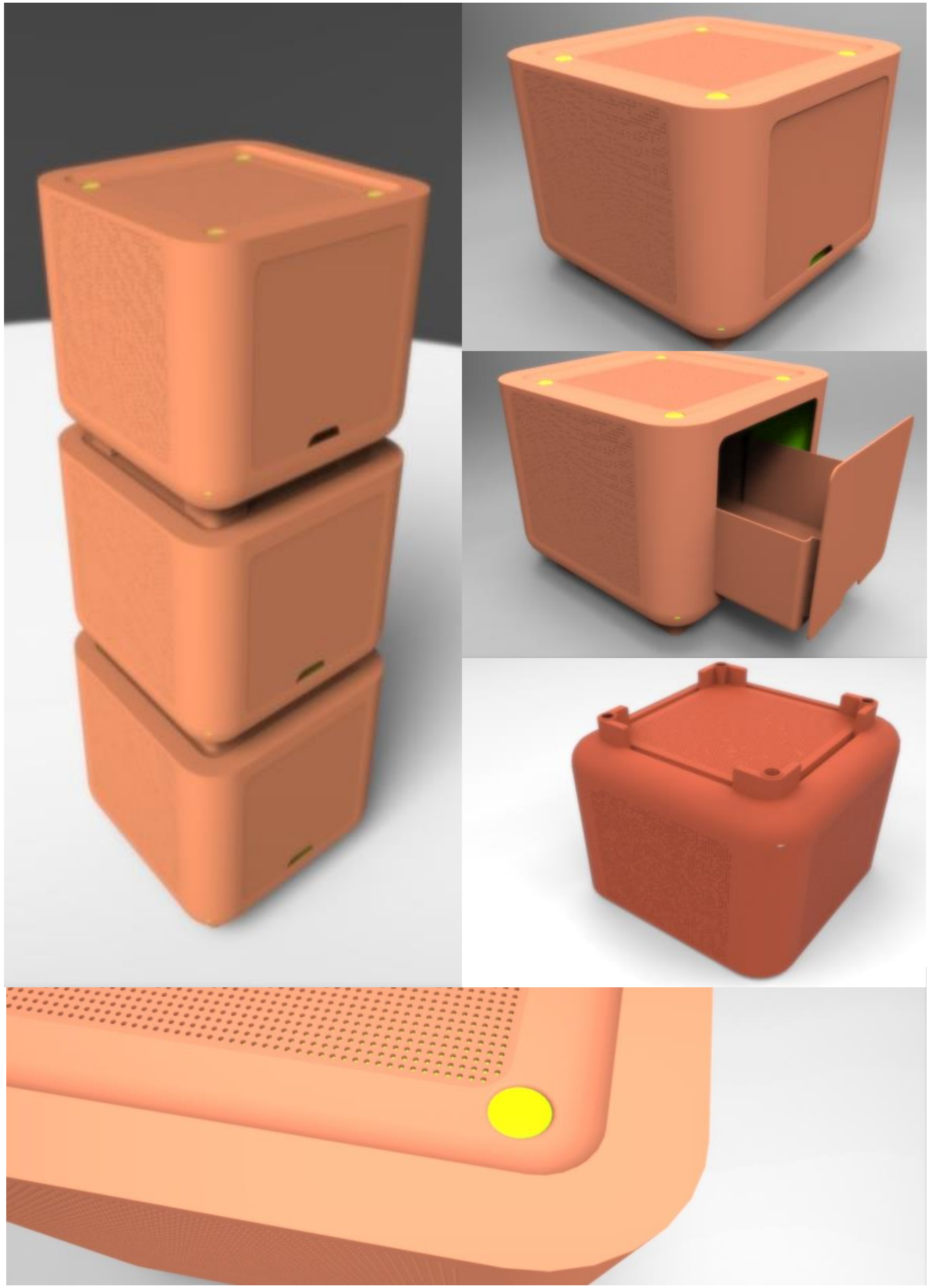


Figure 21: CAD renderings. Tofas, N. 2014.

# 5 THE FINAL DESIGN

## 5.1 PRODUCT EXPLINATION

A storage unit consist of an assembly of various components including: the main casing with in-moulded brass inserts, the drawer, the shelf, the perforated walls and a cellulose sponge component. Fully assembled, one storage unit has the overall dimensions of 440mm x 515mm. Central to the use of the product is the way in which many units are used in conjunction with one another. This section of the document will explain all the features of the design as a single unit as well as in modularity. Aspects will be discussed in terms of functionality, user interface and aesthetics.

Functionality includes aspects that revolve around the process of evaporative cooling. The perforated sheets on 5 of the six sides offer 60% surface area exposure of the moist cellulose sponge. The feet elevate the units from the ground and allow stacking one upon the other. This allows evaporation to happen on the top and bottom surfaces of the units. The units are watered from the top via four holes. The top surface is indented to create a reservoir for water if the units are watered with a hose pipe (figure 22). Alternatively, four 'Coke' bottles can be filled and a small hole made in their lid, these are then placed in each of the holes in the top recess (figure 22). When stacked upon one another, the four holes on the top correspond with four holes in the feet. As the top unit is watered, the sponge inside will saturate, the excess water will then drip into the units below (figure 22). The sponge offers a capillary action of approximately 180mm. The parameters of the top and bottom surface have been calculated so that water is able to reach the centre of each surface (figure 22). In the prototype testing of tests 5,6,7 and 8, it was deduced the thermal conductivity of aluminium assists the decrease of

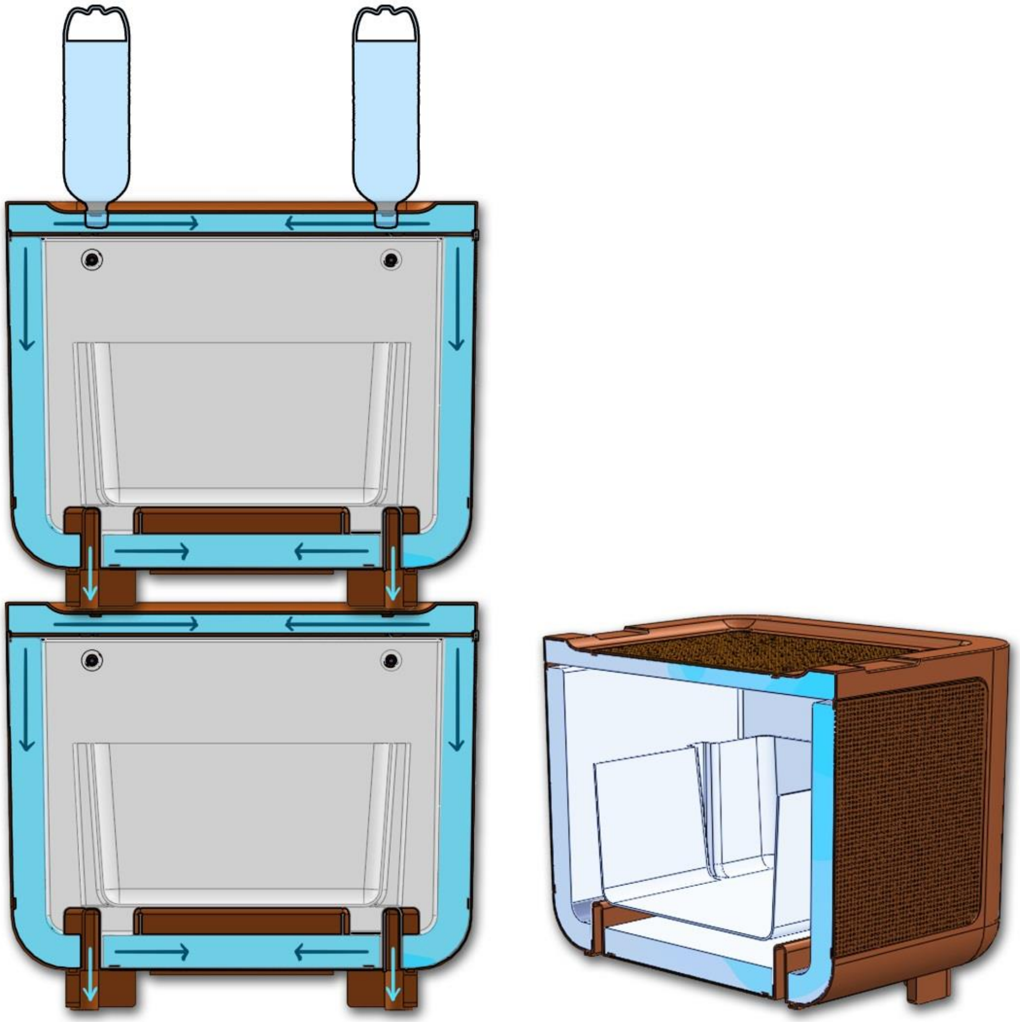


Figure 22: Explanatory render. Tofas, N. 2014.

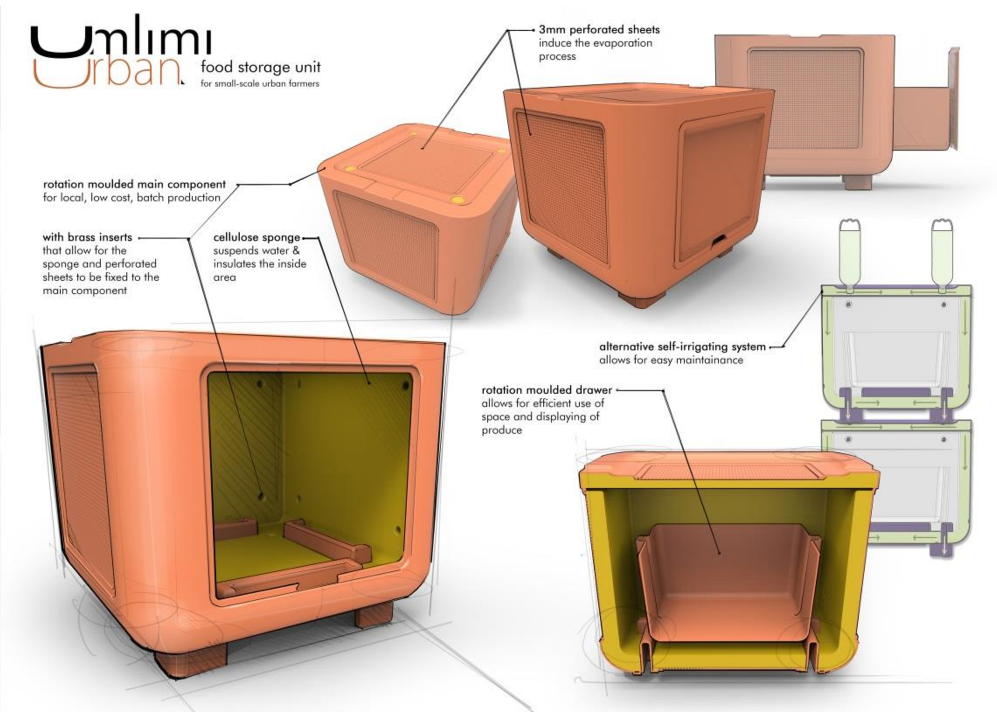



**Figure 23:** Product explanation. Tofas, N. 2014.

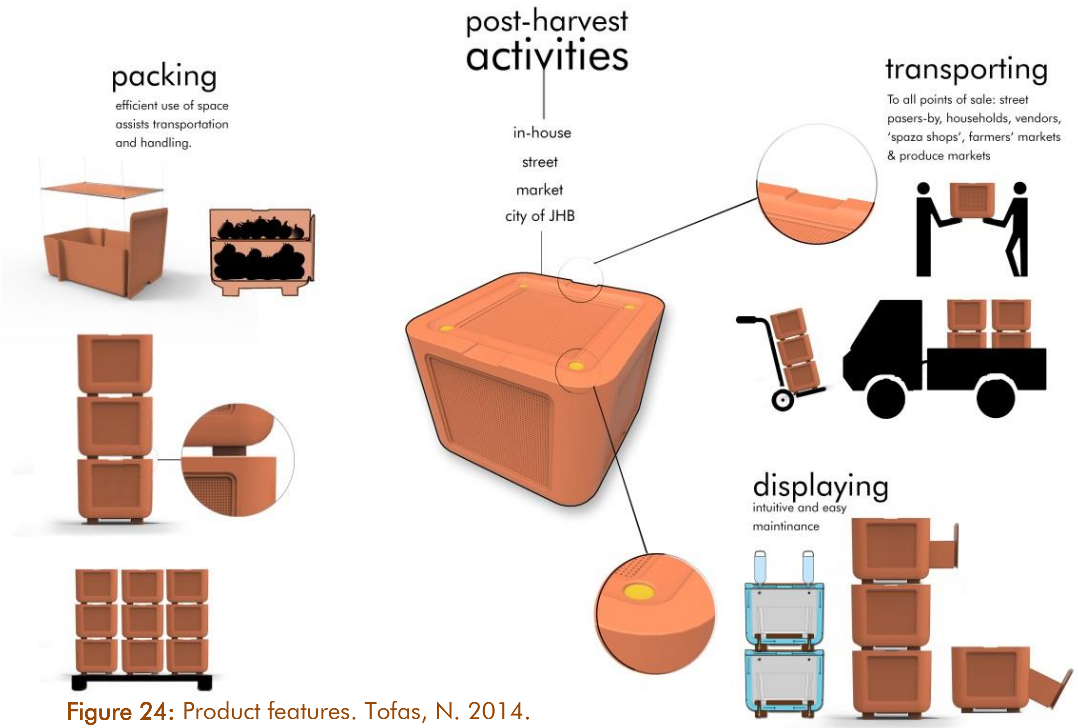



**Figure 24:** Product features. Tofas, N. 2014.

temperature. In order for the cooling principle to work it is critical, not that there is a conductive inner pot, but that there is no insulation between the sponge and the inner area of the pot. As this was realised through desktop research, the aluminium interior was replace with an air and vapour permeable membrane that is fused to the cellulose sponge. This eliminated a costly physical component of the design, simplifying its manufacture and assembly. The membrane being used does not inhibit the thermal conductivity whilst it prevents water from entering the inner area of the storage. This means that if the water being used to maintain the system is not food safe, the produce inside will not be affected. This is critical with reference to the context of use, as a farmer is then able to utilise almost any resource of water that is available.

Aspects around user interface include packing, stacking, transportation and displaying. The drawer can be entirely removed to aid the packing of produce (figure 25 top left). The shelf can then be packed with produce or ice and inserted with ease (figure 25 top left). The units are easily lifted by hand as the base has a large radius and is elevated from the ground. As the feet correspond with the four holes on the top, units align with ease and are stable when stacked (figure 22 & 25).

Transportation via standard trolleys and 'bakkies' (figure 25) relate to design considerations such as: indents in the top surface that allows the farmer to strap the units down (figure 25) and rubber on the feet that prevent the units from sliding around during transportation. Produce inside the units can be displayed during selling. This can be done by opening the drawers (figure 24 & 25). This was designed in such a way that not all the produce has to be exposed at the same time. Once the drawer is opened, the bottom half is kept cooler, by the shelf covering it, while the top half is displayed (figure 25

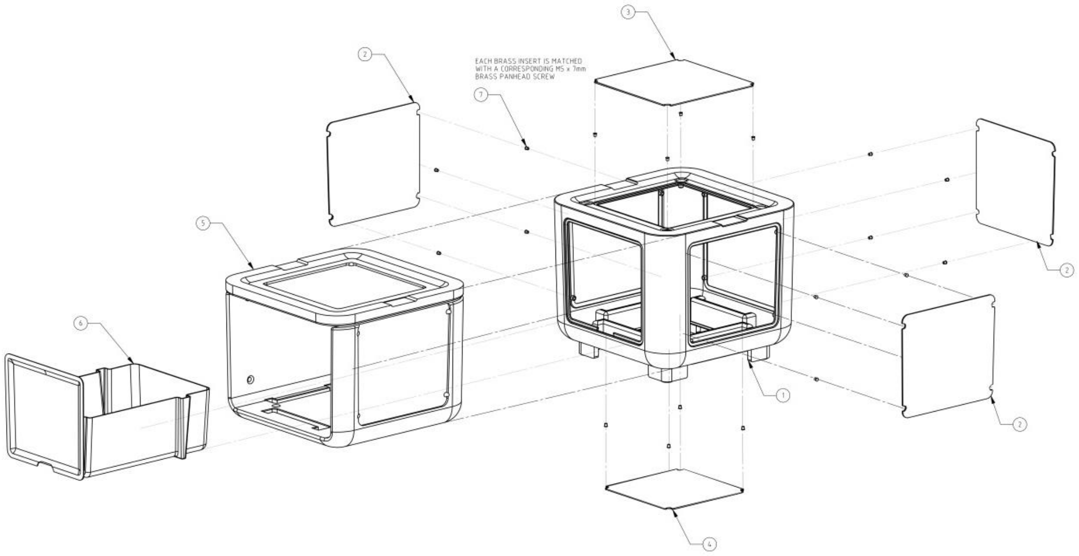


Figure 25: Exploded view. Tofas, N. 2014.

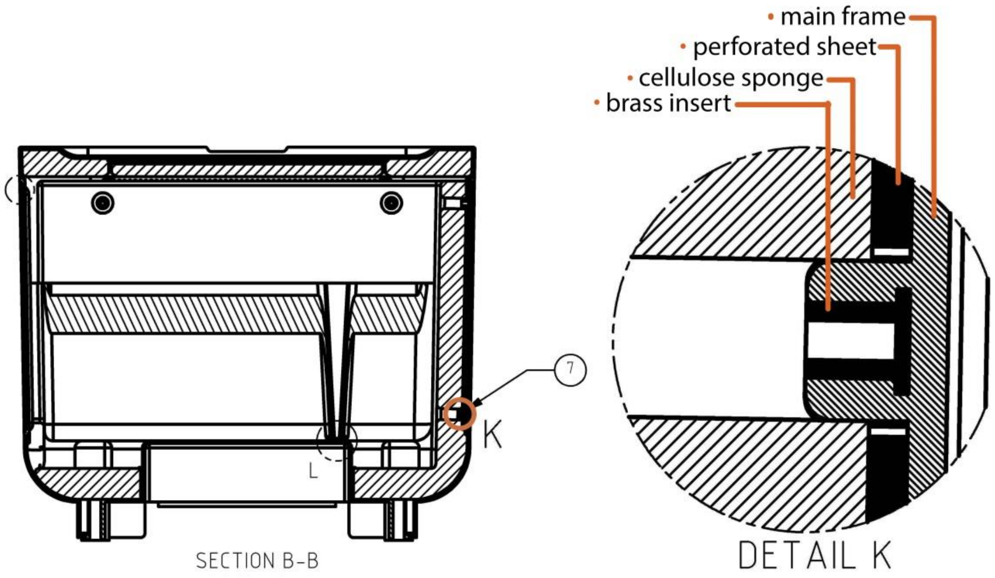



Figure 26: Fastening detail. Tofas, N. 2014.

bottom right). Once the top half of produce is sold, the shelf can be removed. Once the bottom half of produce is sold, the next storage unit can be opened. The shelf is optional as it would obstruct the upright display of spinach. If smaller produce is being displayed, then the shelf assists with a more efficient use of space. There is also an option for ice to be placed on the perforated shelf, to further decrease the temperature and increase the moisture within the unit. The aesthetic of the product is clean so that it is intuitive to use. It visually refers to the Zeer in its simplicity and terracotta colour. A more contemporary colour is included subtly in the cellulose sponge, to retain the product's elegance and to hint at the use of modern technology and materiality.

## 5.2 MANUFACTURE

The main casing, the drawer and the shelf have been designed for the manufacturing process of rotational moulding. Nick Swardt (2014/10/17), the technical manager of *Pioneer Plastics,* states that the rotation moulding the main casing is certainly possible. *Pioneer Plastics* is a professional rotation moulding company in the South African manufacturing industry. The drawer and shelf are designed to be produced from one mould. Once release from the mould, the part is cut along a predetermined guideline, resulting in two separate components (figure 27). Tooling is relatively inexpensive and the process is suited to low volume production runs.

Costing for the product has been calculated per unit based on the assumption that a batch of 1000 units is being produced. The costing will reduce as the batch number increases (refer to costing table). Polyethylene (PE) was chosen as it is the most commonly used material in rotation moulding (Thompson 2007:38). The parts that are rotation moulded are designed for the requirements of this manufacturing process. Some of these specifications include avoiding: sharp angles, tight corners, dramatic undercuts, large flat

| COSTING TABLE | |
|---|---|
| **Production preparation** | |
| moulds | R40 000 |
| dies | R20 000 |
| | **R60 000** |
| Tools last up to 5 000 units | R12 per unit |
| **Production per unit** | |
| Material for moulding | R50 |
| Perforated material & sponge | R90 + R70 = R160 |
| Brass inserts | R20 |
| Assembly & packaging | R100 |
| Distribution | R15 |
| **TOTAL** | **R360 per unit** |

**Figure 27:** Drawer and shelf. Tofas, N. 2014.

**Figure 28:** Logo design. Tofas, N. 2014.

sides and high gloss finishes (Thompson 2007:38) A 3mm wall thickness is incorporated into the design and the 3% shrinking after production has been considered. On each side of the main frame, there are indents which correspond with the perforated sheets. Technically, these can be classified as undercuts for the two part mould. But considering the 3% shrinkage after rotation moulding, these slight undercuts will release from the mould. Additives will be used to make the material UV and weather resistant (Thompson 2007:38). The logo graphic as well as brass inserts will be in-moulded to avoid secondary finishing processes. The standard brass inserts (M5 x 7mm) correspond with fasteners that fix the cellulose sponge and perforated plastic sheets to the main component (figure 26).

The cellulose sponge is die cut from a flat 30mm sheet into a shape that folds to match the inside of the storage container (figure 25). The 5 perforated sheets are die cut from standard perforated sheets of plastic and correspond with each side of the main frame that has been shrouded during rotation moulding (figure 25).

## 5.4 BRANDING

The name of the product was inspired by its users namely, urban farmers. Most of the participants spoke Zulu as their first language. The name Umlimi Urban was chosen as this is a direct translation of the English term 'the urban farmer' into Zulu. The logo was designed to fit the simple, yet elegant styling of the product (figure 28). The shape of the units and their stacking is symbolised by the U's in both words. The colour of terracotta in the Zeer was used in the product's design. The logo is not far removed from this reference as the same colour has been carried through in the word 'urban'.

# 6 CONCLUSION & RECOMENDATIONS

## 6.1 CLOSING STATEMENT

### 6.1.1 SUMMARY OF OUTCOMES

The study attempted to design a short term, off-grid storage unit appropriate for small-scale urban farmers in Soweto. This was led by the assumption that such a product could assist the farmers to emerge into their local economy.

The aim was to create a product that successfully facilitates the climate controlled transport of produce to points of purchase with the prospect of growth to the farms' full potential. Evaporative cooling, as explored in the literature review, was mimicked and successfully altered to suit this project's specific context of use. Similarly to how the precedent studies, in chapter two, were appropriately designed for each of their contexts, by following co-design methods, this project achieved something relevant to the farmers' context of use. Through the realisation of the Umlimi Urban food storage, the traditional African method of evaporative cooling used in the Zeer, has been presented in a light that is not so far removed from this African point of origin.

Contributing to the field of industrial design, this design intervention has harnessed the advantages of modern technology and materiality, and combined them with a traditional off-grid cooling method. Attempting to contribute to the field of urban agriculture, this solution has emanated from the theory of Brian Nummer (2002: [sp]), who promotes reconnecting with traditional methods to create roots in local lands. By following this inspiration throughout the project, the solution has, built into it, the potential to in some small way develop already formed communities and the livelihoods of its people. By studying the post-harvest flaws of small-scale urban farmers and designing accordingly, utilisation of the Umlimi Urban food storage could potentially correct the post-harvest handling of produce, increasing the potential for future success of a farm.

The solution was created through a progressive realisation of the problem ecosystem. Through a process of PAR the intervention was an attempt at satisfying the requirements of PTD and SI. The participatory theories emphasise iterative processes. This project incorporated this theory as much as possible, but with the time limit, this cycle had a cut-off point. Ideally, more in depth iterations would most likely reveal issues such as security of the units on the farm site as well as at points of sale.

Time could have been saved if the prototypes, testing principle, were tested prior to the roll-out on Siyazenzela. This short-fall touches on the point made by Czech Conroy and Alistar Sutherland (2004:1), stating that information about the technology should be available to the users in the research domain. Providing information, about the complexities of evaporative cooling during use, proved difficult and was perhaps not executed in the most efficient way.

It was predetermined that the product needed to be sustainable within the context, this included operations such as manufacture, distribution, accessibility, use and maintenance. With regards to the manufacture of the main casing, drawer and shelf, they could only be manufactured in Johannesburg as opposed to Soweto specifically. It is also probable that die cutting the perforated sheets and sponge will not be manufactured in Soweto. There is, however, an opportunity to assemble and package the unit in Soweto, taking advantage of local skills and resources.

With regards to distribution, the product could be made available at many retail stores in Soweto, making it accessible to most small scale-farmers in the community. Included in the business plan is the option of locally storing assembled units with the intent of renting them to farmers. This involves dropping off and picking up the units at the farmers' points of sale. Managing this rental system would involve employing two members of the community. This makes the unit available to farmers at a price lower than cost price. In terms of maintenance, the design is durable within its context. The assembly works in such a way that if a component breaks, it can be replaced without replacing the entire product.

The participatory sessions with the farmers revealed how the storage product could be an investment that aided post-harvest productivity on a farm. The research question of, how the design and development of the solution could help to empower the farmers to be more productive, was thus progressively realised and incorporated into the design.

### 6.1.2 RECCOMMENDATIONS FOR FURTHER STUDY

Although much of the design criteria was established through iterative prototyping, feedback was somewhat limited by the project's limited resource of time. This allowed for critical thinking around aspects of functionality, user interface and aesthetics, but limited the long term user feedback that is needed to truly critique the design. As one of the main points of use was at the market, it would be useful to observe the product being used in this context. This observation proved unrealistic as markets only happen monthly, and only so many markets happened throughout the length of this process.

Using the off-grid cooling method of evaporative cooling proved to be advantageous in many ways. The method, however, brings limitations to the design in the way that its performance is dependent on the surrounding temperature, humidity and wind. Fortunately, the product will generally operate successfully with regards to weather conditions in South Africa. The function of the product relies on the users' accessibility to shade. Upon a user's first experience with this product, they might not be aware of these aspects that the design relies on. Something that was inescapable was building into the product knowledge about evaporative cooling that was sourced in a variety of ways. Although the product's interface is successfully intuitive, less intuitive are the details of how evaporative cooling functions. A further recommendation would be to provide a user manual that includes additional information about the product.

**modularity**

grows with the farm,
suitable to all size farms
stacking,

**transportability**

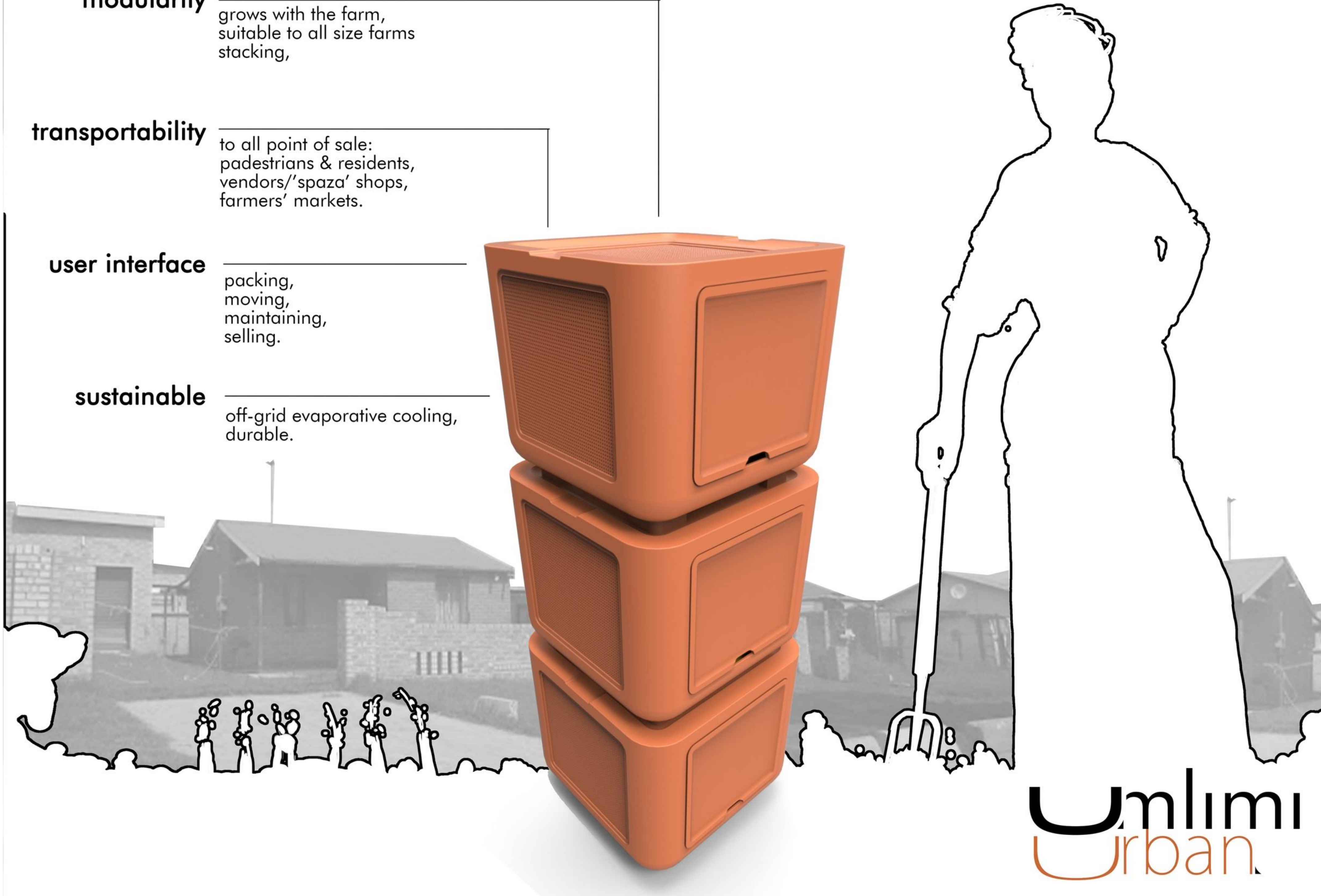
to all point of sale:
padestrians & residents,
vendors/'spaza' shops,
farmers' markets.

**user interface**

packing,
moving,
maintaining,
selling.

**sustainable**

off-grid evaporative cooling,
durable.



Umlimi
Urban.

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