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RESEARCH REPORT

An exploratory study on barriers to implementing household-scale vertical food production in Plastic View, Pretoria East

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Declaration of originality

I declare that the mini-dissertation, "An exploratory study on barriers to implementing household-scale vertical food production in Plastic View, Pretoria East," which has been submitted in fulfilment of part of the requirements for the module of DIT 801, at the University of Pretoria, is my own work and has not previously been submitted by me for any degree at the University of Pretoria or any other tertiary institution.

I declare that I obtained the applicable research ethics approval in order to conduct the research that has been described in this dissertation.

I declare that I have observed the ethical standards required in terms of the University of Pretoria's ethic code for researchers and have followed the policy guidelines for responsible research.

Signature: ……

Date: 26.07.23

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Abstract. South Africa and the rest of the world are not making satisfactory progress in addressing many of the issues listed by the United Nations in their 2030 Agenda for Sustainable Development, namely those relating to hunger and malnutrition. These are particularly prevalent issues in South Africa, where many households do not have access to adequate foods to maintain a healthy lifestyle. The Plastic View informal community – situated in Pretoria East, Gauteng – is one such community battling poverty and food insecurity. Urban agriculture has become a "knee-jerk" reaction to the need for household-scale food production. However, ground space is scarce in dense cities and informal communities and is considered more valuable for basic living requirements than crops by communities. A possible solution to this challenge may be food production through living wall systems. This would provide a range of ecosystem services in cities and allow households with spatial limitations to engage in small-scale food production for personal or economic gain. Through an exploratory and interpretivist approach, this study seeks to understand barriers to using living wall systems to support household-scale food production in the Plastic View informal community, and how residents currently view household-scale food production and associated barriers. The study concludes that, while the advantages of living wall systems are acknowledged by residents, affordability, and skill to build or maintain the systems were notable factors of concern.

Keywords: Living wall systems, Urban agriculture, Vertical food production, Informal communities, Food security, South Africa, Household-scale food production

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List of Acronyms

ALVs: African leafy vegetables
GI: Green infrastructure
LWS: Living wall system
SDG: Sustainable Development Goal
TAVs: Traditional African vegetables
UA: Urban agriculture
WHO: World Health Organisation

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1. Introduction

The United Nations stated in their 2030 Agenda for Sustainable Development that their goals were ambitious and that they were aware of the monumental challenges involved in eradicating all poverty. Evidently, seven years away from the due date, South Africa and the rest of the world are not making satisfactory progress in addressing issues of hunger and malnutrition (SDG 2), the need for resilient infrastructure (SDG 9), income inequality (SDG 10), bad living situations and human settlement planning (SDG 11) (United Nations Statistics Division, 2015).

Food security is particularly concerning in South Africa, where income inequality is rated amongst the highest globally. Altman et al. (2009) explain that while, as a country, we may be producing ample amounts of food to feed the population, many individual households cannot access enough food to combat hunger and maintain a healthy, nutritional lifestyle. A steady expansion of cities and urban sprawl exacerbates the challenge of providing access to adequate quality and nutritious food. Grebitus et al. (2020) state that the single way to mitigate the growing resource demand may be through urban agriculture.

Urban agriculture (UA) can simultaneously address food security, societal health, local ecology and urban heat islands, etc., providing a holistically better urban environment. A study by Battersby and Marshak (2013) conducted in Cape Town conveyed that, besides the benefits listed above, UA improved 'participants' perceived physical and mental well-being through their engagement in growing food and helped communities develop a positive collective identity.

While traditional in-ground forms of UA may boast societal health benefits, household food availability, and economic assistance, it does not consider the spatial constraints of informal communities and city dwellers. However, living wall systems (LWSs) may present a solution to this problem. LWSs are an approach to green walls which should not be confused with green façades; green façades can be described as a ‘green curtain’ comprised of climbing plants growing from a substrate at the base of the wall and supported vertically by trellises or the wall itself. Alternatively, LWSs present a modular approach to green walls – these consist of planters with growing medium separated from the wall through waterproofing, thereby incorporating vegetation into the structure. Due to LWSs not relying on in-ground planting, they can support a larger variety of plants, thus, having a greater impact on biodiversity enhancement and ecosystem service. LWSs are forms of Green Infrastructure (GI) due to their contributions to provisioning, regulatory, supporting, and cultural ecosystem services. Furthermore, living walls can offer increased urban environmental benefits compared to green roofs (Manso and Castro-Gomes, 2015); this assists in mitigating urban heat islands, sequestering carbon, improving urban biodiversity, and absorbing city noise pollution.

Although LWSs provide significant benefits in terms of GI, their current installation and maintenance costs tend to be high; thus, their economic sustainability requires mitigation. Vertical food production in LWSs could be a feasible solution for their economic unfeasibility, as edible crops could be produced at a commercial scale on limited areas of land. However, as

Nagle et al. (2017) and Botes and Breed (2021) state, further design and development efforts are needed to simplify complicated technologies to adapt living wall systems to a larger scale and lower cost applications. This would also improve the systems' functionality in informal urban areas. Were living wall systems more accessible to a wider range of people – concerning the costs and skill required for installation – they could provide a positive way forward for households battling with food insecurity and economic challenges.

Cloete and Idsardi (2013) state that traditional African vegetables (TAVs) or African leafy vegetables (ALVs) have a significant role to play in addressing food insecurity and malnutrition. TAVs or ALVs are defined by Towns and Shackleton (2019) as “plant species that are indigenous or naturalised to Africa, well adapted to or selected for local conditions, whose plant parts are used as a vegetable, and whose modes of cultivation, collection, preparation, and consumption are deeply embedded in local cuisine, culture, folklore, and language.” Many of these vegetables contain rich amounts of protein and micronutrients essential for human health. They offer a substantially higher nutritional value than mainstream vegetables such as lettuce or tomatoes (Uusiku et al., 2010, Akinola et al., 2020). Using these crops in a South African environment has several additional advantages, such as their increased resistance to adverse local climates and lower maintenance requirements than mainstream vegetables (Botes and Breed, 2022, Cloete and Idsardi, 2013). The ease with which ALVs can be grown due to their climate tolerance and low maintenance requirements could provide households with a way to mitigate food insecurity and malnutrition. These crops could be produced in higher quantities on smaller land areas when coupled with living wall systems.

While vertical food production may seem like a straightforward solution for food insecurity, economic unsustainability, and the lack of urban land, traditional LWSs pose many challenges for informal communities. Most green wall systems currently in the market have been designed for wealthy urban contexts – this is evident through their highly technical irrigation requirements, expensive installation costs, complex structures, and high maintenance requirements. These factors may cause impoverished communities to hesitate to adopt the more efficient crop cultivation method. Nevertheless, many more basic options are available to people who do not possess the money or expertise necessary for the upkeep of modern systems. Such options include using recycled materials such as cold drink bottles, plastic pipes, or pots suspended vertically containing a growing medium and plants. These 'low-tech' solutions could provide the same advantages in mitigating food insecurity through spatially efficient food production while removing issues of financial limitations or lack of skill.

Figure 01: Plastic View locality (Author, 2023), Image: Google Earth Pro (2023)

Plastic View (*Figure 01*) is an informal urban community in Pretoria East, Gauteng. Plastic View has been selected as the study area, as it stands as a clear example of South Africa's issue of income inequality as it is close to the affluent neighbourhoods of Moreleta Park, Woodhill, and Mooikloof. In 2015 the camp was home to an estimated 3000 individuals (Matlhabe, 2015), 75% of whom were reported to be undocumented foreign nationals (Kgosana, 2018) from surrounding African countries – such as Zimbabwe, Lesotho, Botswana, and Mozambique – who travelled to South Africa in search of work. In addition to the people of Plastic View battling poverty and unemployment, they are challenged by a severe lack of space, with roughly 6.5 hectares of land to share between the 3000 residents. With the rising food costs and minimal ground space to establish crops, there exists great difficulty for people residing in informal communities to provide a household with adequate food for a healthy lifestyle.

While the residents of Plastic View may not have the ground space to produce sufficient crops to sustain a family or reap the economic benefits of urban farming, they may be able to find value in 'low-tech' vertical food production systems. This study aims to investigate the following:

- What barriers exist in using living wall systems to support household-scale food production in the Plastic View informal community in Pretoria East?
    - What are the current perceptions of the Plastic View residents related to household-scale food production?
    - How does the Plastic View informal community perceive the opportunities and barriers to using living wall systems for household-scale food production in terms of their environments, needs and limitations?

This study follows the structure illustrated in *Figure 02* below. The introduction chapter is followed by the scoping literature review chapter to identify the nature of previous research and gaps in the existing literature. The third chapter, the research method, covers the study area, data collection and analysis. Chapter 4, the results, provides a discussion and graphic illustrations of the findings. In Chapter 5, the discussion section, results are translated into recommendations for possible developments in the field and compared with the relevance of past and future studies.

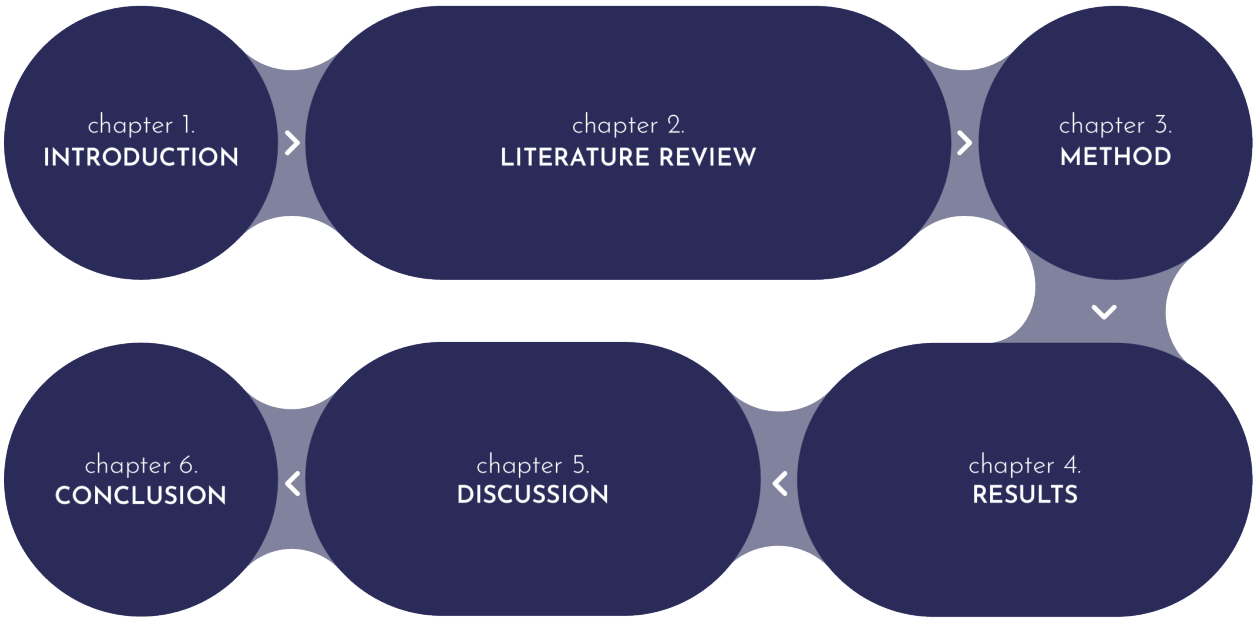

Figure 02: Report structure (Author, 2023)

2. Literature Review

The literature review aims to establish the current realm within which this study's research questions are positioned and to situate the study within the context of the 2030 Agenda for Sustainable Development (United Nations Statistics Division, 2015). Possible barriers or adaptations needed concerning LWSs in the context of the Plastic View informal community need to be understood. This includes understanding the larger-scale issue of food insecurity and under-nutrition throughout South Africa, the relationship between food insecurity, under-nutrition and UA, and the country's limitations relating to UA. The review then looks at the integration of UA with LWSs and ways in which the sustainability and resilience of LWSs can be improved. One way of improving sustainability and resilience is through crop selection (Botes and Breed, 2021). The literature review then focuses on the utilisation of ALVs and how they can be beneficial in LWSs in terms of economic and ecological sustainability. This chapter concludes by exploring existing applications of edible LWSs in informal communities and the additional benefits these provide for households, aside from increased food security and nutrition.

2.1. Food insecurity in South Africa

With food security, poverty, and undernutrition being the most consequential challenges globally, steps must be taken to ensure that poor and vulnerable people have access to sufficient nutritious food (United Nations Statistics Division, 2015). Many factors contribute to the growing threat of food security globally. These include a rapidly growing population and climate change presenting new challenges in food supply systems and farming practices (Godfrey, 2021). With the global urban population expected to grow to 6.4 billion people by 2050, increased carbon emissions with larger quantities of food transported from rural areas are anticipated (Eigenbrod and Gruda, 2014).

The issue of food security in the South African context is one of profound complexity and concern, with income inequality and levels of extreme poverty being ranked amongst the highest globally (Altman et al., 2009). According to Stats SA (2021), 2.6 million South African households have inadequate access to food, while 1.12 million have severely inadequate access to food. Altman et al. (2009) state that to understand food security, one must first understand the multitude of elements that influence individuals' access to adequate food, such as the food supply system, unemployment, rising food prices, and household income. While these are key influential factors in the inaccessibility to sufficient food, they also present substantial challenges in households receiving the necessary nutrients and vitamins in their diets to maintain healthy lifestyles. The importance of diverse and nutritional diets can be seen in undernutrition's adverse, life-long effects on children. These effects include poor cognitive development, decreased immune functions, and lowered learning abilities as irreversible effects (Altman et al., 2009).

Aliber (2009) builds on the prevalence of food insecurity in South Africa by looking into the number of households using agriculture to mitigate their lack of access to adequate food. The results show that 4 million South African Labour Force Survey respondents said they engaged

in urban agriculture as an additional food source. At the same time, women made up 61% of all respondents involved in urban agricultural activities. This dominance was most prevalent in the category of farmers who aimed to produce an additional source of food for their households.

2.2 Urban agriculture to address food insecurity for South African informal communities

With urbanisation increasing rapidly globally and in South Africa, there is a spike in food demand and a drop in land availability in cities. This increases urban waste, dependency on global and national food markets, and ecological footprints (Eigenbrod and Gruda, 2014). To improve South Africa's response to food insecurity, undernutrition, carbon emissions, and climate change, vacant spaces in cities need to be utilised more productively. Eigenbrod and Gruda (2014) state that UA can combat these large-scale issues through its characteristically low carbon footprint, transparent food system, and contribution to the local economy. Furthermore, UA can benefit undersupplied and vulnerable communities such as South Africa by providing additional food sources and employment opportunities. Eigenbrod and Gruda (2014) define UA as an organised system within a built-up area that produces and distributes a diverse food product selection, involving the use or reuse of material and human resources, and the utilisation of services from in and around the local vicinity.

While UA has shown nutritional health benefits by providing 'participants' with additional healthy food sources, it also positively affects mental health. Battersby and Marshak (2013) state that individuals who spend time being active in the garden feel several psychological benefits, such as a sense of purpose or fulfilment and relief from daily worries. Many participants in this study also mentioned a sense of pride associated with a successful garden (Battersby and Marshak, 2013). Additionally, UA provides advantages at a community scale (Battersby and Marshak, 2013). These include giving people a shared purpose, thus, bringing communities closer together and instilling a sense of collective support for one another. Due to the increased interaction among neighbours and increased 'eyes on the street,' crime was also reported to decrease within the study community; however, vandalism and theft continued to concern participants (Battersby and Marshak, 2013).

Cilliers et al. (2020) confirm that most individuals who participate in UA do so to improve their access to food. This study also points out that cities with higher economic decline and limited employment opportunities tend to engage more with UA, making it evident that personal food production is a commonly employed response to food insecurity issues (Cilliers et al., 2020). Citizen-led urban agricultural approaches have been said to show higher levels of engagement and participation and thus receive an increased buy-in from the public (Cilliers et al., 2020). Urban vegetable production is the most successful form of citizen-led approach to urban agriculture due to its highly profitable nature (Eigenbrod and Gruda, 2014). Due to the short growing cycles and nutritional values of vegetables, these crops can meet individual food demands relatively quickly while not requiring highly intensive irrigation or fertilisation (Eigenbrod and Gruda, 2014).

2.3 Current urban agriculture limitations for South African informal communities

Although individuals support citizen-led approaches to UA, Cilliers et al. (2020) state that these practices rely heavily on additional support measures such as local authorities, professionals, or NGOs. These actors provide financial, logistical, and educational support (Cilliers et al., 2020). Education on UA plays a vital role in the success of a project to ensure ample engagement among communities, and this may also assist in destigmatising any possible negative perceptions of UA (Cilliers et al., 2020) (Grebitus et al., 2020).

Another challenge facing UA in a South African context is the limited support from existing policies (Cilliers et al., 2020). To address the broader goal of food security, national policies need to be implemented to guide the planning and management of UA initiatives. Currently, neither the National Environmental Management Act (1998), the Spatial Land Use Management Act (2013), nor the National Policy on Food and Nutrition Security (2013) contains a direct reference to UA practices. However, each document refers to principles that UA could support, such as sustainable land development, social inclusion, food security, and environmental objectives (Cilliers et al., 2020). Furthermore, would UA planning and management policies be developed, South Africa still faces safety and security challenges, water shortages, and a lack of land (Du Toit et al., 2022).

A study conducted by Du Toit et al. (2022) in Potchefstroom, North West Province, investigates the participation of informal community residents in UA. Further to the lack of policy support for UA, the study by Du Toit et al. (2022) provides insight into reasons for communities not partaking in UA. Their findings show that while most residents experienced inefficient space, available areas were rather filled with lawn, ornamental plants, traditional spiritual use plants, or bare soil (Du Toit et al., 2022). The reason for this is that residents felt concerned vegetation would provide spaces for criminals to hide in, thus, open spaces were reported to increase a household's sense of security (Du Toit et al., 2022). Moreover, Du Toit et al. (2022) indicated that the preferred use of ornamental plants provided a sense of status and luxury, showing higher regard among the community for cultural ecosystem services than food production.

2.4 Living wall systems for household-scale food production in South African informal communities

LWSs offer a possible solution for the lack of available land in rapidly urbanising cities, and as the desire for safety, as expressed by Du Toit et al. (2022). LWSs can maximise environmental benefits without taking up valuable space or compromising views to the street. In addition, LWSs provide greater benefits than green roofs or in-ground planting as the vertical surfaces of buildings can be up to double their ground footprint (Manso and Castro-Gomes, 2015). Similarly to in-ground UA initiatives, green walls can provide a host of environmental advantages for urban spaces – including biodiversity enhancement, stormwater management, dust control, improved air quality, and urban heat island mitigation – while simultaneously improving the performance of buildings through the reduction of energy demands for heating and cooling, due to their ability to provide shade or insulation (Sheweka and Mohamed, 2012). Modular LWSs are encompassed within the common term 'living wall' and allow the inclusion

of a wider range of plant species, owing to a growing medium in modular planters (Manso and Castro-Gomes, 2015).

Modular LWSs are currently the most popular systems in the South African market; this can be due to their instant visual effect after installation and ease of maintenance due to each plant being grown in its own tray or vessel (Botes and Breed, 2021). There are limited options available when it comes to locally manufactured modular LWS, three examples are the Eco Green Wall, Vicinity, and Modiwall (Botes and Breed, 2021).

While LWSs can provide numerous environmental benefits and improve the sustainability and performance of buildings, they tend to be costly systems to install and maintain. This is largely due to their complexity and structural materials (Manso and Castro-Gomes, 2015). However, a solution to their financial limitations is presented by the development of local, low-cost systems, as well as the possibility of incorporating edible plant species (Mårtensson et al., 2016); (Russo et al., 2017); (Botes and Breed, 2022).

The Eco Green Wall (*Figures 03 and 04*) has been developed to address the challenges facing outdoor LWSs in a South African context. This has been achieved by protecting the planting cavities from light exposure to prevent moisture loss, the long lifespan of the structure due to its durable materials, simple installation of the lightweight interlocking blocks, and commercially available soil trays (Arbus Horticulture, 2020). The carbon footprint of this system has also been reduced through its use of recycled polystyrene in the bricks' construction (Arbus Horticulture, 2020). This system represents a feasible solution to the lack of space for UA in informal communities, economic constraints and safety issues caused by dense in-ground planting.

Figure 03: Eco Green Wall (Arbus Horticulture, 2020)

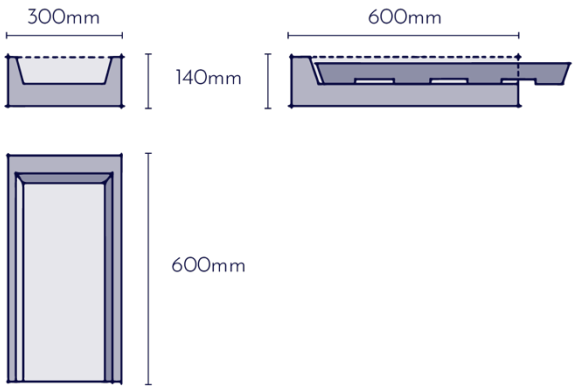

Figure 04: Eco Green Wall dimensions (Author, 2023)

By integrating UA with LWSs, financial feasibility can be improved through the harvesting and economic benefits of useful and edible crops (Mårtensson et al., 2016). Nevertheless, LWSs pose limitations in terms of maintenance when involving edible plants. For example, Botes and Breed (2022) mention the height of some large-scale LWSs above the ground as presenting challenges for harvesting, light availability, and ensuring equal irrigation to all

levels of the system. In addition to these logistical issues, climatic concerns remain prevalent in growing vegetables in LWSs. However, through careful crop selection, most of these difficulties can be mitigated. In a study conducted by Nagle et al. (2017), yields of LWSs were compared to those of traditional in-ground production methods using a selection of different crops. It was found that leafy vegetables such as collard greens, Swiss chard, mei qing choi, and radishes with greens grown in a LWS had a harvest rate 3-5 times that of the same crops grown in-ground. In addition to this, the 7.5m^2 LWS was able to produce more than the daily requirement of vegetables (400g per person recommended by the World Health Organization (WHO) (2020) for a healthy diet during the growing season (Nagle et al., 2017).

While Eigenbrod and Gruda (2014) state that urban vegetable production is a feasible solution to individual food insecurity due to high yields, relatively low maintenance, and short growing cycles, they emphasise extreme weather conditions and changing climates as the most significant threats to urban food production. The difficulties in growing vegetables in LWSs present similar challenges. Droughts, storms, and extreme temperature changes impact on crop yields, whether plants are grown in the ground or vertically.

2.5 Perceived barriers to African leafy vegetable production amongst South African informal communities

African leafy vegetables (ALVs) have a far higher tolerance to adverse South African climates than 'mainstream' vegetables such as cabbage or tomatoes (Uusiku et al., 2010). Akinola et al. (2020) explain that Sub-Saharan Africa is highly vulnerable to climate change due to its low adaptive capacity; this presents the need for a shift in focus towards alternative crops, which promote increased resilience in agricultural systems. ALVs show successful adaptivity and resilience to changes in climate and enable new methods of tackling environmental challenges in farming. Akinola et al. (2020) also report that ALVs are well adapted to poor soil conditions, pests, and fires while additionally showing benefits of improving water conservation efforts and reducing soil erosion. Integrating the cultivation of 'mainstream' crops and ALVs can lower the need for agrochemicals without impacting yields (Akinola et al., 2020).

While ALVs can reduce crop production costs through their resilience to adverse climates and provide environmental benefits in reducing water usage and soil improvement, they also boast many nutritional benefits (Akinola et al., 2020). These benefits include the high levels of various micronutrients, antioxidants, and dietary fiber in raw ALVs (Uusiku et al., 2010). Along with their antioxidant abilities and dietary fiber levels, ALVs contain high amounts of vitamin A, which is imperative in tackling under-nutrition – especially in children (Steyn et al., 2001). Therefore, ALVs could present a viable solution to South Africa's issue of food insecurity and undernutrition if used to supplement staple diets.

Although ALVs offer economic, nutritional, and environmental benefits, their consumption in South Africa has declined (Cloete and Idsardi, 2013). Subsistence farmers in KwaZulu-Natal perceive ALVs as poverty crops, old fashioned, or wild (Modi, 2003). The study by Cloete and Idsardi (2013), conducted amongst households in the North West Province, showed that some respondent households viewed ALVs as having a poor image. The most common motivation

for not consuming these vegetables was ignorance and limited availability. However, many households are reported to enjoy ALVs due to their affordability and taste. (Cloete and Idsardi, 2013)

2.6 Living wall systems with African leafy vegetables for informal communities

Many South Africans who participate in UA do so to provide their household with a primary or additional food source (Cilliers et al. 2020; Aliber 2009). Stephen Lamb and Andrew Lord developed the 'Green Shack' (*Figures 05 and 06*) as a precedent for future sustainable additions to marginalised communities' living situations (Design Indaba, 2013).

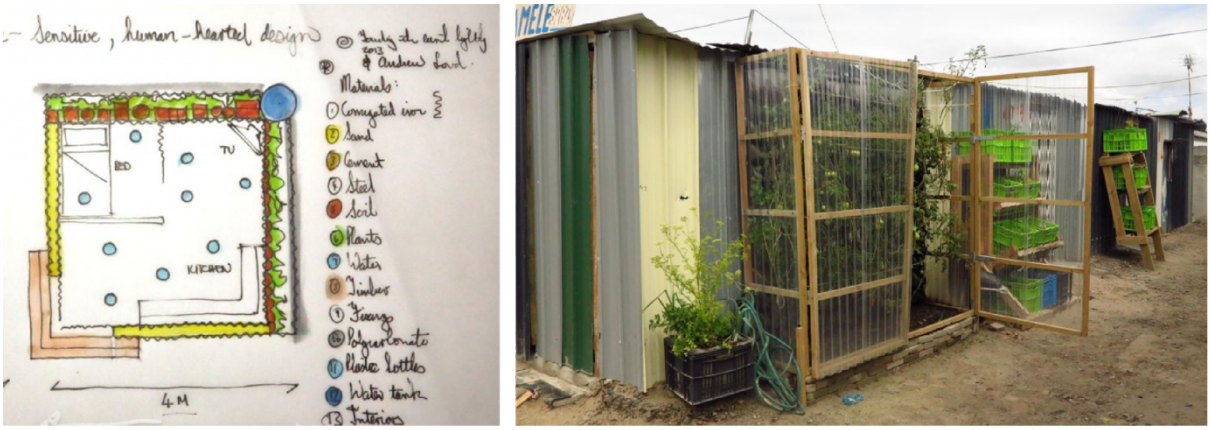

Figure 05 and 06: The Green Shack (Design Indaba, 2013)

The structure incorporates low-cost and low-tech vertical farm systems on two of its outer walls, which use gravity-fed drip irrigation from rainwater harvested from the roof. The vertical garden is protected from vandalism, theft, and winds by transparent sheeting, which encloses the crops in a greenhouse-like structure. While this low-tech LWS supports household food security, it is also able to regulate the temperature within the shack (Design Indaba, 2013).

Given ALVs' high adaptivity to adverse climatic conditions and their high nutritional value, they could provide a feasible way forward in addressing food insecurity and undernutrition in South Africa. ALVs could show particular success if incorporated into low-tech systems such as the 'Green Shack' or the Eco Green Wall system. Furthermore, ALVs grown in LWSs show the potential to impact food insecurity and undernutrition without taking up valuable ground space (Botes and Breed, 2022). Two case studies within Gauteng, South Africa, explored by Botes and Breed (2021), display the successes and failures of indigenous crops grown in living walls. The resilience of LWSs and the indigenous crops in the first case study is shown through a minimal 15% crop loss when plants could not be attended to due to a two-month COVID-19 lockdown implemented during the plants' early establishment phase. Similar results were displayed in the second case study, where irrigation complications left plants without water for between three and four weeks; this resulted in a mere 30% loss of plants (Botes and Breed, 2021).

These examples show the importance of crop selection in edible LWSs, as the small soil volumes of planting trays can enhance challenging climatic conditions. Further challenges revealed by the case studies include wall aspects affecting light and heat exposure, wind tunnels in highly urban environments, and glare from surrounding buildings (Botes and Breed, 2021). ALVs are naturally well-suited to cope with these challenges (Akinola et al., 2020). ALVs would therefore be appropriate low-maintenance, low-cost, and resilient additions to LWSs to impact food insecurity and under-nutrition.

2.7 Concluding reflections

The literature review shows that the residents of South African informal communities' experience food insecurity and undernutrition. This is mainly due to the high levels of extreme poverty and a deficiency in vitamin A among children. Citizen-led efforts to mitigate these challenges are mainly comprised of communal and household-scale vegetable gardens to provide an additional source of food for households. However, multiple difficulties and limitations are opposing UA initiatives in South Africa. These include the lack of policies supporting formal UA initiatives, financial limitations within low-income communities, and concerns for safety.

Low-tech LWSs such as the Eco Green Wall and the 'Green Shack' propose feasible responses to these challenges through durable, affordable, and user-friendly designs. When integrated with suitable plant palettes such as ALVs, such systems could provide vulnerable communities with a reliable and resilient way of providing households with a main or additional source of nutritious food. The literature reviewed did not provide any insight into additional barriers within informal communities in utilising LWSs, aside from the security or income constraints associated with UA. Negative perceptions of ALVs included these crops having a poor image. However, many households continue to enjoy ALVs due to their taste and affordability.

3. Research Methodology

3.1 Selected research approach and design

In the landscape architectural profession, multiple informants guide questions in research and practice, leading to research within the field, borrowing methods developed in other realms, such as the social or natural sciences (Bruns et al., 2017); (Swaffield and Deming, 2011). This leads to the field often employing a pragmatic approach, which enables the researcher to draw on multiple paradigms or methods to answer the questions best and appropriately relate the study to human experiences (University of Nottingham, n.d.). Swaffield and Deming (2011) suggest that methodological integrity and fitness for purpose are critical factors in landscape architectural research.

This research follows a pragmatic philosophy. Swaffield and Deming (2011) mention that a pragmatic approach is conducive to producing transferrable knowledge that can be applied in real-world situations. Due to very little existing information on the barriers to using living wall systems to support household-scale food production in the Plastic View informal community, an exploratory inductive research approach has been followed. Swedberg (2020) and Du Toit (2015) describe the purpose of this methodology as intending to develop initial ideas or techniques for further research on a particular topic, prompting more specific questions for subsequent investigation.

This study aims to gather quantitative and qualitative information to answer the main research question and sub-questions. As this research project is concerned with understanding socio-economic and socio-ecological systems within Plastic View, it utilises qualitative descriptive strategies in collecting and recording information. Leedy and Ormrod (2015) explain this strategic approach as the act of observing situations without making any alterations to the social or physical environment. Du Toit (2015) also describes descriptive research approaches as painting an accurate picture of reality driven by practical and applicable aims.

3.2 Motivating Plastic View as the study site

Plastic View's location amongst affluent suburbs demonstrates income inequality in South Africa. The community has been plagued by unsanitary conditions, crime, and poverty since its establishment due to poor support from municipal services (Sibiya, 2019) and difficulty finding work among many people due to their lack of South African documentation (Mashika, 2019). An attempt to counter this was made in 2019 by SA Cares for Life, an NGO focused on uplifting the lives of children in vulnerable positions; this initiative included the establishment of a food programme within Plastic View to tackle under-nutrition and food security (Sibiya, 2019).

Plastic View’s desperation for food was, however, displayed once again in 2020 despite SA Cares for Life’s efforts when ‘good Samaritans’ handing out food parcels to residents of the community were caught in commotion when there was not enough food to feed everyone who was in need (Sibiya, 2020). The consistent struggle among residents for sufficient food was a driving factor in the choice of Plastic View as the study site, as this research seeks to understand whether vertical food production systems could be a viable solution to alleviate hunger and what barriers currently exist in implementing household-scale food production schemes.

3.3 Data collection method and instruments

According to Leedy and Ormrod (2015), survey research involves uncovering information such as opinions, experiences, or characteristics of a group of people by asking a sample of the population a series of carefully designed questions, the answers to which are then quantitatively analysed. Furthermore, the study used correlational research methods to observe the extent to which characteristics or patterns expressed by the sample group influenced other variables (Leedy and Ormrod, 2015). This research project made use of these research methods in the form of semi-structured, face-to-face questionnaires combined with photo-elicitation. Leedy and Ormrod (2015) elaborate on the discernment between structured and semi-structured interviews or questionnaires; structured questionnaires will focus on asking specific questions with no further explanation required from the participants, while semi-structured questionnaires allow the participant to expand on answers to give more clarity or reasoning. For this study to fully understand the barriers influencing household-scale food production in Plastic View, the questionnaire was designed to allow participants to introduce additional answers which may not have been accounted for in the set of options provided. Furthermore, photo-elicitation was used to eliminate possible language barriers between the researcher and participants (photographs used can be seen in *Annexure A*). As stated by Bignante (2010), incorporating photographs into the interview or questionnaire process is a means of enriching responses by presenting different insights and prompting associations unknown to the researcher – specifically surrounding the knowledge of African leafy vegetables or the use of easy-to-use, 'low-tech' living wall systems within the Plastic View community.

Participants of this study were asked questions verbally by the researcher, and an accompanying community leader assisted with translating and scribing for participants who could not write or read English well enough. The community leader provided consent to assist through her acknowledgement of the study cover letter (*Annexure B*). Participants were shown collages of images with a selection of ALVs and a collage showing basic living wall systems as part of the questionnaires to provide respondents with a visual reference of the questions' topics or to prompt further insight in answers. Face-to-face interviews were chosen over telephonic or electronic interviews based on the lack of technology available to the participants to improve the response rates.

The questionnaires (*Annexure C*) were designed to take approximately 20 to 30 minutes to complete. This is suggested by Leedy and Ormrod (2015), who advise that people value their time greatly and are more likely to engage with the questions if they perceive them to be short, simple, and straightforward. The questionnaire used 'yes or no' answering systems and questions with set answer options, including a final option for the participants to specify any additional answers that may not have been accounted for. These were combined with rating scale questions. Leedy and Ormrod (2015) explain that rating scales can be productive methods of obtaining information on attitudes or preferences in a questionnaire or interview process. These types of questions consist of several options for participants to respond within the case of this study: 'agree,' 'disagree,' and 'neither agree nor disagree' regarding possible challenges in growing vegetables. Each response option in the questionnaire correlated with numeric values to simplify the data analysis process. In the case of open-ended questions, numeric values were assigned accordingly to the vegetables listed as part of the data analysis preparation. In the case of open-ended questions, qualitative analysis was done by grouping similar responses and assigning numeric values accordingly. With questions regarding vegetables grown or recognized by participants, categories were created to encompass all types of vegetables specified. These included ALVs (tsunga, kale, rape, or covo), mainstream leafy

vegetables (lettuce or cabbage), mainstream root vegetables (carrots, potato, or onions), mainstream vine plants (tomatoes, beans, or pumpkins), and maize.

Before beginning the questionnaire, participants were asked verbally for their consent and afterwards, they were left with a participant slip, which contained contact details of the researcher as well as confirmation and thanks for completing the questions (see *Annexure D*)

3.4 Population and sample group

Questionnaires were conducted over two days amongst randomly selected residents from the Plastic View informal community. To ensure a representative sample, the researcher entered the study site at different locations, namely the Northern gate (*Figure 07*) and the central gate adjacent to the clinic, in Plastic View's Western and central parts. Residents over the age of 18 were randomly selected.

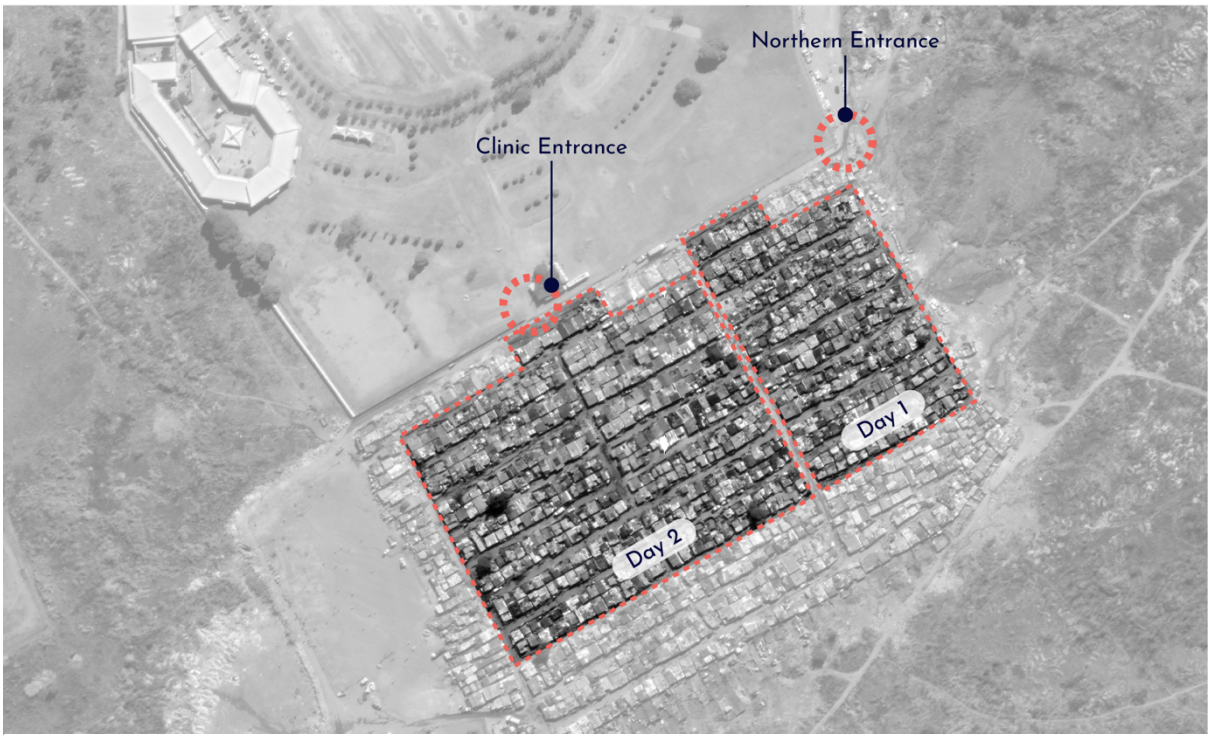

Figure 07: Areas covered for questionnaires (Author, 2023), Image: Google Earth Pro (2023)

The questionnaire was completed by 50 residents of Plastic View, 25 on the first day and 25 on the second day.

3.5 Data analysis

A quantitative methodology was followed by analysing data statistically. IBM SPSS Statistics (Version 28.0.1.0 for Mac) was chosen for conducting simple analyses between selected variables. Before the data's input into the SPSS software, the researcher manually coded questionnaire sheets and transferred them onto a Microsoft Excel spreadsheet. This process ensured that the data was formatted correctly for the statistics software to read it accurately. This required all answers attached to numerical values to be transferred into a spreadsheet.

A Pearson correlation coefficient test was conducted to determine the relationship between demographics and the perceived challenges of growing vegetables and LWSs. A 95%

confidence ($p < 0.05$) interval was used to test for statistically significant correlations between the variables collected.

3.6 Ethics, bias, and reflexivity in the research

When conducting research, ethical processes must be followed. Following ethical approval by the Faculty of Engineering, Built Environment and Information Technology (EBIT) at the University of Pretoria, specific protocols were followed to comply with the approval (*Annexure E*). Conditions included that consent should be obtained before conducting interviews or questionnaires and that participants should be informed that their responses will be shared as findings. The community leadership agreed on behalf of the community to participate in the study. The study's purpose was explained to each individual who signed a consent letter attached to the questionnaire. Each participant also received a participant slip (*Annexure D*) containing the researcher's contact details – were they to have any further queries – and confirmation that they had consented to engage with the study.

An additional challenge when engaging with people in research studies is the possible expectation among residents that physical changes will be implemented, driven by the misunderstanding of the research purposes. This is shown by Makakavhule (2021) when a few participants in her study expressed concern and disapproval that they would never see results or that the research would not have any impact on their day-to-day lives. To avoid issues such as this, the respondents from Plastic View were informed prior to the questionnaire process that no physical benefits would prevail from the study.

When undertaking questionnaire research, it is essential to acknowledge possible bias and the effects of the researcher's expectations, beliefs, and worldviews when interpreting data or designing questions. Jamieson et al. (2023) describe this phenomenon as reflexivity in research, which is corroborated by Leedy and Ormrod (2015), who state that "*no human being can be completely objective.*" With this understanding in mind, attempts to mitigate subjectivity were made through random sampling of the Plastic View population, the testing of all variables for correlational relationships before omitting variables which proved irrelevant to the research questions, as well as the interpretation of the data being based on quantitative findings rather than personal assumptions.

3.7 Concluding reflections

Despite the limitations and challenges mentioned above, engagement with the residents of Plastic View and the data collection process successfully captured adequate data to answer the project's research questions. Due to the practical nature of the landscape architectural profession, the data collection and analysis processes chosen are deemed appropriate to produce outcomes applicable in real-world situations.

4. Results

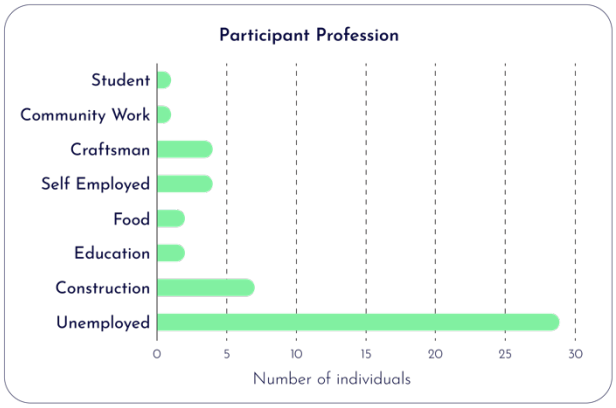

Figure 08: Participant profession (Author, 2023)

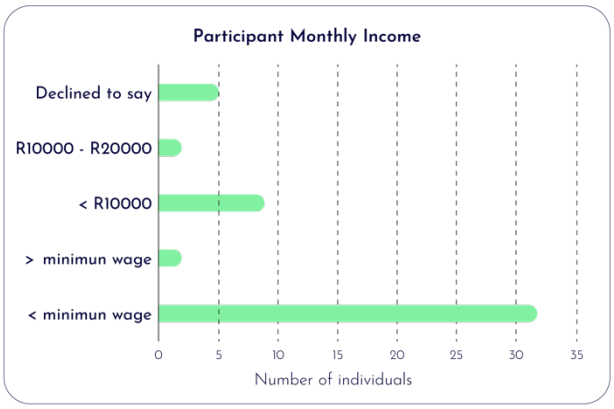

Figure 09: Participant income (Author, 2023)

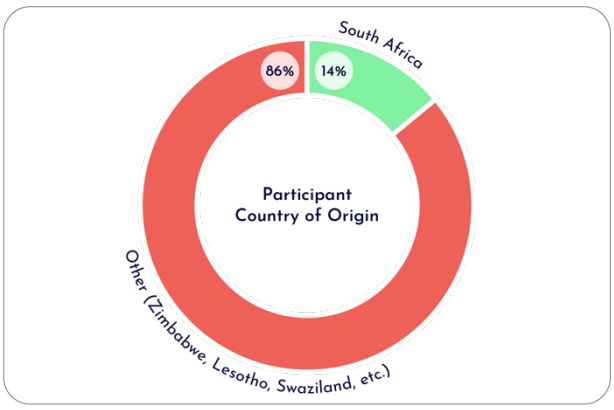

Figure 10: Participant country of origin (Author, 2023)

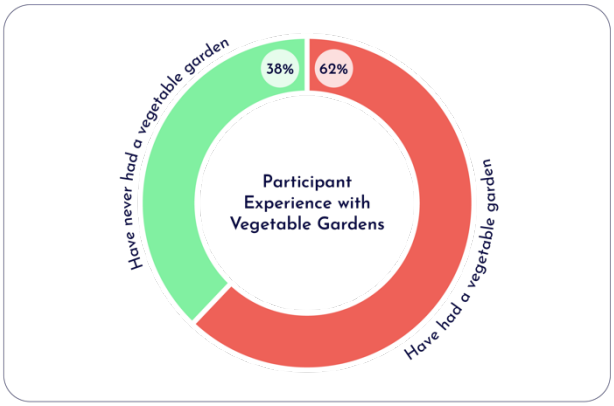

Figure 11: Participants experience with vegetable gardens (Author, 2023)

4.1 Sample characteristics

Of the 50 individuals who participated in the questionnaire, 42% (21 people) were between 20 and 29 years old. 36% of respondents (18 people) were between 30 and 39 years old, only 6 people were between 40 and 49 years old, and 4 people were between 50 and 59 years old. Only one respondent was 18, and none of the participants was over the age of 60. 31 of the respondents were female (62%), while only 19 (38%) were male.

Figure 08 shows that 58% of respondents (29 people) stated they were unemployed, 14% (7 people) worked in construction. In contrast, the remainder of respondents claimed to be involved in occupations such as food, education, craftsmanship jobs (painting, mechanics, or carpentry), or community development work. In contrast, 4 individuals stated that they were self-employed. Relating to the majority of respondents having no formal employment, 64% (32 individuals) said that they earn below the minimum wage, 2 people claimed to earn above minimum wage, 9 people earned less than R10 000 per month, 2 people earned between R10 000 and R20 000 per month, while 5 of the respondents declined to share their income with the researcher (see *Figure 09*).

As can be seen from *Figure 10*, only 14% of respondents grew up in South Africa, and 86% of respondents were originally from other African countries such as Zimbabwe, Lesotho, Swaziland, Malawi, or Namibia. Most respondents (62%, as can be seen in *Figure 11)* reported that they had a vegetable garden at the time of the questionnaires or that they, at some point in the past, had a vegetable garden. However, 38% of respondents said they had never had a vegetable garden.

4.2 Biggest challenges in growing vegetables

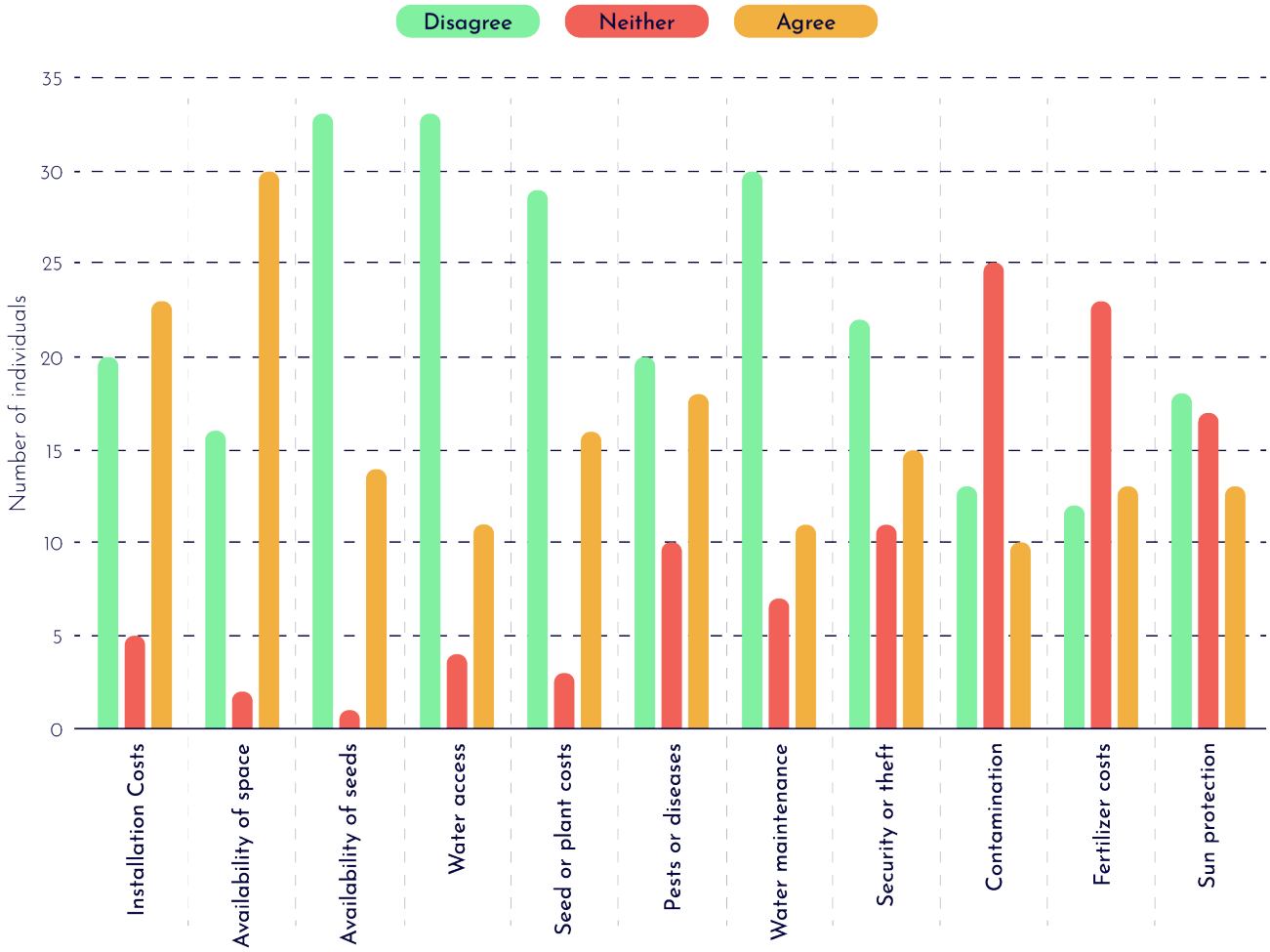

Figure 12: Graph showing the biggest challenges in growing vegetables (Author, 2023)

The results (displayed in *Figure 12*) show that space availability was the most significant challenge in growing vegetables, with 30 out of 48 individuals stating that they agreed with the statement. The second most prominent challenge in growing vegetables, as stated by 23 people, was installation costs. However, 20 people conversely disagreed that costs were not an issue. In terms of the availability of seeds, access to water, seed or plant costs, security or theft, and maintenance regarding the watering of plants, substantially more people disagreed as opposed to agreeing that these factors presented challenges. Thirty-three people disagreed with the statement of the availability of seeds and access to water being a challenge, 29 people disagreed that the cost of seeds or plants was a challenge, 22 people disagreed that security or theft was a challenge. In comparison, 30 people disagreed with the statement that maintenance with regard to watering plants was a challenge. When it comes to pests or diseases and sun protection, the number of people who agreed and disagreed that these were challenges were similar, with 20 people disagreeing, 18 agreeing, and 10 people stating that they felt neither way about pests or diseases, and 18 disagreeing, 13 agreeing, and 17 people stating that they felt neither way about sun protection. Regarding the challenges of contamination and the cost of fertilizers, most people (25 and 23 people, respectively) responded that they neither agreed nor disagreed that these were challenges they faced. However, 13 people stated that contamination was a challenge, while 12 people perceived the cost of fertilizers to be a challenge.

4.3 Perceived advantages and disadvantages of using living wall systems for household-scale food production

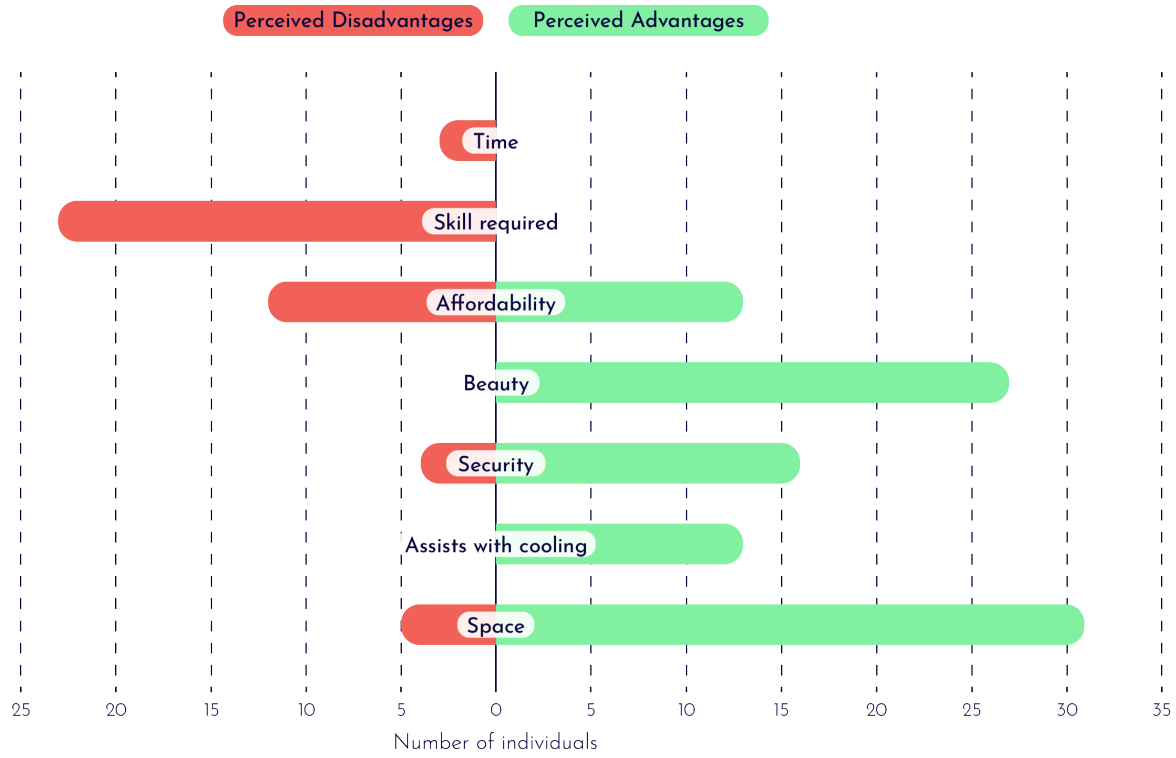

Figure 13: Graph showing the perceived advantages and disadvantages of using LWSs for household-scale food production (Author, 2023)

Regarding the perceived benefits of using LWSs for household-scale food production, 31 out of the 34 individuals who responded to this question stated that they believed a living wall would help save space when limited land is available (as seen in *Figure 13*). Twenty-seven people said that a LWS would improve the beauty of their living environment. In comparison, 16 people felt that the system would have positive impacts on safety and security as it can be installed closer to the house or shack. Thirteen out of the 34 respondents to this question stated that they believed a LWS would be more affordable than in-ground food production and that the system could assist with cooling the interior of their house or shack.

Of the 35 individuals who responded to questions relating to disadvantages, 23 people stated that they did not know how to build or maintain the system, while 3 specified that they did not have sufficient time to build or maintain such a system. As stated previously, 13 respondents believed LWSs would be more affordable to build and maintain than in-ground planting. However, 12 individuals stated that they believed LWSs would be more costly. Four respondents mentioned an additional perceived disadvantage would be safety due to theft or vandalism, as opposed to the 16 people who felt otherwise. In contrast to the 31 people who felt that a LWS could save space, 5 stated they did not have sufficient space for a LWS.

4.4 Correlational relationships

Table 1: Results from Pearson correlation test showing correlations between gender and income of participants who have or have previously had a vegetable garden, and their reasons for growing vegetables (Author, 2023)

		To Eat	Economic Benefits	Enjoyment	Nutrition
Gender	Pearson Correlation	-0,317	0,029	-0,230	**-0.372***
	Sig. (2-tailed)	0,082	0,876	0,213	0,039
	N	31	31	31	31
Income	Pearson Correlation	0,162	0,014	**0.387***	0,266
	Sig. (2-tailed)	0,384	0,940	0,032	0,148
	N	31	31	31	31
To Eat	Pearson Correlation	1	-0,297	**0.361***	**0.412***
	Sig. (2-tailed)		0,105	0,046	0,021
	N	31	31	31	31

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The raw data (*Annexure F*) shows that most people who grew vegetables did so to eat (28 out of 31 respondents) and for nutritional reasons (19 out of 31), with fewer people (17 out of 31) stating that they grow vegetables for the economic benefits or for enjoyment. A Pearson correlation coefficient was conducted to assess the linear relationship between participant' gender and income and their reasons for growing vegetables (as seen in IBM SPSS output files – *Annexure G*). *Table 1* shows that there is a statistically significant negative correlation between the participants' gender and growing vegetables for nutrition ($r = -0.372$, $p = 0.039$). When investigating the raw data to understand what caused this correlation, it was found that more men than women stated that they grew vegetables for nutritional purposes – 12 men and 7 women.

As can be seen in *Table 1*, there is a statistically significant positive correlation ($r = 0.387$, $p = 0.032$) between income and growing vegetables for enjoyment. When cross-checked with the raw data, this was found to be the result of 10 out of the 17 people who stated that they grow vegetables for enjoyment, also earning below minimum wage. There is a statistically significant positive correlation between growing vegetables to eat and growing vegetables for enjoyment ($r = 0.361$, $p = 0.046$). This is due to 17 out of the 28 people who stated that they grow vegetables to eat and that they grow vegetables for enjoyment. There is a statistically significant positive correlation ($r = 0.412$, $p = 0.021$) between growing food to eat and growing food for nutritional reasons. This is due to 19 out of the 28 people who stated that they grow food to eat, also growing food for its nutrition.

Table 2: Results from Pearson correlation test showing correlations between participant's gender, profession, and income, their familiarity with LWSs, the likelihood of participants using LWSs, and whether the participant has their own vegetable garden or rather purchases vegetables (Author, 2023)

		Own Vegetable Garden	Purchasing Vegetables	LWS Familiarity	LWS Possible Usage
Gender	Pearson Correlation	-0,273	0.330*	-.371**	0.321*
	Sig. (2-tailed)	0,055	0,019	0,008	0,023
	N	50	50	50	50
Profession	Pearson Correlation	0,130	-0.322*	0.330*	-0,204
	Sig. (2-tailed)	0,367	0,023	0,019	0,155
	N	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

While the data shows that all 50 questionnaire respondents stated that they eat vegetables, 40 of the participants said that they buy their vegetables. A Pearson correlation coefficient was conducted between participant's gender, profession, and income, their familiarity with LWSs, the likelihood of participants using a LWS, and whether participants had their own vegetable garden or bought vegetables (as can be seen in IBM SPSS output files – *Annexure G*). As seen in *Table 2*, there is a statistically significant positive correlation between purchasing vegetables and participant gender ($r = 0.330$, $p = 0.019$) – the data shows that this is due to 28 women stating that they buy vegetables, while only 12 men stated the same. There exists a statistically significant negative correlation between purchasing vegetables and profession ($r = -0.322$, $p = 0.023$). This is due to 26 out of the 40 people who buy vegetables also stating that they are unemployed.

The respondents' familiarity with LWSs was split evenly, with 25 people stating that they had not seen a living wall system before, while 25 people stated that they had. The Pearson correlation coefficient conducted between LWS familiarity and profession shows a statistically significant positive correlation ($r = 0.330$, $p = 0.019$). This is due to 18 out of the 25 people who were not familiar with LWSs being unemployed.

While most respondents stated that they would use a LWSs (31 out of 50), *Table 2* shows a statistically significant positive correlation ($r = 0.321$, $p = 0.023$) between gender and the possible usage of LWSs – 23 women indicated that they would grow vegetables in a living wall to provide food for their household, while only 8 men stated the same.

5. Discussion

5.1 Summary of key findings

This study aims to investigate LWSs supporting household-scale food production to mitigate food insecurity, under-nutrition, economic constraints, and lack of land in the Plastic View informal community in Pretoria East. This chapter will discuss the study's results in relation to the research questions:

- What barriers exist in using living wall systems to support household-scale food production in the Plastic View informal community in Pretoria East?
    - What are the current perceptions of the Plastic View residents related to household-scale food production?
    - How does the Plastic View informal community perceive the opportunities and barriers to using living wall systems for household-scale food production in terms of their environments, needs and limitations?

The literature review concluded that low-tech LWSs growing ALVs could present a reliable and resilient solution to food insecurity and under-nutrition in informal communities (Cloete and Idsardi, 2013, Akinola et al., 2020, Botes and Breed, 2022). Many South African households are reported to engage in UA to provide an additional source of food for their household (Aliber, 2009). However, there are a number of negative perceptions and barriers standing in the way of people's utilisation of UA, ALVs, and LWSs in informal communities; these included security, costs, poor image, and a lack of space (Du Toit et al., 2022, Manso and Castro-Gomes, 2015, Modi, 2003).

Space availability was the most common constraint in growing vegetables, with installation costs being the second most prominent challenge. Other factors such as the availability of seeds, access to water, costs of seeds or plants, security or theft, and maintenance received more disagreement than agreement. The majority of respondents reported buying vegetables rather than growing them, with women being more likely to do so. While most people who engaged in UA activities stated that they grow vegetables to eat, more men than women claimed to grow vegetables for nutritional purposes. Most people who stated that they grow vegetables for enjoyment earned below minimum wage.

When asked about the advantages or disadvantages of using LWSs, most respondents believed that LWSs could save space, with the second and third most recognised advantages being improved aesthetics and increased security. Limitations to using LWSs were shown by many respondents stating that knowledge, skills, or cost required to build and maintain the system would be an issue. A Pearson correlation coefficient showed that women had a higher inclination to use a LWS for household-scale vegetable production. While familiarity with LWSs was evenly split between respondents, unemployed individuals were less familiar.

5.2 Interpretations

5.2.1 What are the current perceptions of the Plastic View residents related to household-scale food production?

The results show that, while all respondents stated that they eat vegetables, most opted to purchase instead of growing them. This can be attributed to the high level of concern shown for factors such as available space and installation costs – which is in agreement with findings from Du Toit et al. (2022). Further to this, a second controversial result is presented by the majority of people who stated that they preferred to buy vegetables rather than grow them,

being unemployed. As the costs of plants, seeds, and fertiliser were found not to be a concern to most respondents, the unwillingness to grow vegetables among individuals without a consistent income could be tied to a lack of knowledge or skill. In response to this, Cilliers et al. (2020) and Grebitus et al. (2020) both confirm that education on the benefits and processes of UA is a vital factor in its success.

The questionnaires confirmed that most people grow vegetables mainly for the purpose of eating and for nutrition. However, most of the people who stated that they grow vegetables for enjoyment earned below minimum wage. This is an unexpected result which builds on the findings of Aliber (2009), who states that UA is predominantly used to provide a necessary additional food source amongst low-income households. This study provides insight that UA can also provide a recreational activity.

In response to this research question, the residents of Plastic View were found to be in favour of purchasing their vegetables rather than growing them. This can be owed to the lack of space available in the informal community for traditional in-ground forms of UA, financial constraints, and a lack of knowledge or skill to implement alternative solutions. A number of unemployed individuals grow vegetables not only to provide an additional food source but also for personal enjoyment.

5.2.2 How does the Plastic View informal community perceive the opportunities and barriers to using LWSs for household-scale food production in terms of their environments, needs, and limitations?

The questionnaires showed that respondents believed significant advantages of implementing LWSs for household-scale food production would be saved space and increased security. This is consistent with the concerns expressed regarding the lack of land available for traditional in-ground vegetables. Du Toit et al. (2022) found similar results in that safety was a common concern for residents informal communities. In addition, Du Toit et al. (2022) found that ornamental plants were used around homes to display status, which this study confirms by ‘improved aesthetics’ being a highly regarded advantage of using LWSs.

Respondents expressed the greatest limitation in using LWSs as being a lack of knowledge or skills. Furthermore, the unfamiliarity of unemployed residents with LWSs and the poor uptake of UA amongst unemployed individuals could be due to a lack of expertise and knowledge. These findings could, once again, be tied to the emphasis placed on education by Cilliers et al. (2020) and Grebitus et al. (2020).

The result showing that more women than men purchase vegetables could be an indication of household dynamics. This is in agreement with the higher inclination among women to use a LWS for household-scale food production.

This question has been addressed through the results showing that Plastic View residents believe LWSs could mitigate concerns for security relating to in-ground crops and save space. However, a concern was raised over the skills and knowledge necessary to implement the structures. An additional barrier is the unfamiliarity with LWSs among unemployed individuals.

5.2.3 What barriers exist in LWSs to support household-scale food production in the Plastic View informal community in Pretoria East?

Most respondents reported earning below minimum wage or being unemployed, so the significant barrier identified for using a LWS being affordability was expected. The most prevalent concern expressed by respondents was a lack of knowledge or skill to build or maintain a LWS. In addition to this, the lack of familiarity with LWSs among unemployed individuals could be interpreted as a general lack of exposure to these systems being a barrier to their utilisation. These findings are consistent with several sources assessed in the literature review (Botes and Breed, 2022, Cilliers et al., 2020, Grebitus et al., 2020, Mårtensson et al., 2016).

5.3 Implications

The results show that the implementation of low-tech LWSs could assist with addressing many of the concerns felt by the residents of Plastic View relating to traditional in-ground forms of UA, such as the availability of space and installation costs. However, as stated by Cilliers et al. (2020) and Grebitus et al. (2020), education and training would be necessary for such interventions to be adopted by the respondents. This is made clear by the emphasis placed on a lack of knowledge or skill, especially among those who are unemployed.

The concerns expressed by the residents of Plastic View place emphasis on the research conducted by Botes and Breed (2022) and Mårtensson et al. (2016), who both state that while LWSs can benefit those with limited space, they require improvement in terms of their financial feasibility and complex construction. The examples presented in the literature review – the 'Green Shack' (Design Indaba, 2013) and The Eco Green Wall (Arbus Horticulture, 2020) – have recognised these constraints and proposed solutions which incorporate low-tech, resilient systems. However, it would be imperative that education or training programmes be integrated with such implementations to address any misconceptions about installation costs or construction (Cilliers et al., 2020, Grebitus et al., 2020).

5.4 Limitations

With an estimated 3000 individuals residing in Plastic View, a sample size of 50 in this study may be a significant limitation in the reliability and accuracy of the results. Additionally, as a young white female, caution was also taken in approaching individuals or community areas deemed unpredictable and potentially dangerous by the accompanying community leader. The data collection was undertaken during the weekdays, limiting the study to individuals presently at the site and excluding individuals who could have been at work. While this gave an indication of high unemployment rates within the community, the numbers recorded may have been exaggerated. This could present limitations in acquiring a holistic picture from the data collected. Future studies should consider this and adequately prepare for the fieldwork to yield accurate results based on a balanced portion of the population.

6. Conclusion

This research aimed to identify barriers to using living wall systems to support household-scale food production among residents of the Plastic View informal community. The guiding research questions were as follows:

- What barriers exist in using living wall systems to support household-scale food production in the Plastic View informal community in Pretoria East?
    - What are the current perceptions of the Plastic View residents related to household-scale food production?
    - How does the Plastic View informal community perceive the opportunities and barriers to using living wall systems for household-scale food production in terms of their environments, needs and limitations?

Study participants were engaged with using semi-structured, face-to-face questionnaires combined with photo-elicitation. The fieldwork was followed by analysing data from the 50 participants statistically. A review of previous studies led to the expectation that a lack of available land, income constraints, and security concerns would be the predominant barriers in utilising LWSs. This was confirmed by the results of this research, which showed that while the advantages of LWSs were acknowledged by participants, affordability and skill to build or maintain the systems were factors of concern. An additional barrier uncovered by this research was the lack of exposure to LWSs for household-scale food production, as shown by the low levels of familiarity and preferences to purchase vegetables found amongst unemployed and low-earning individuals.

While the limited number of participants may have led to a restricted view of the study group, the results portray a true representation of the high unemployment levels and the large settlement of undocumented foreign nationals. However, further research should be conducted to asses a wider range of participants to gain a more accurate view. Given Plastic View residents' enduring struggles with food insecurity and poverty, the new insights presented by these findings should assist in further experimental research to develop more efficient, effective, and practical solutions.

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Annexure A

Pigweed

Spider Plant

Cowpea

Kale

Traditional pumpkin

Gushe

Bitter melon

Morogo

Cabbage

Tomatoes

Annexure B

Dear Sir/Madam,

I am a researcher in the Department of Architecture, University of Pretoria.

My research titled ***Analysing the barriers in informal urban communities for applying/ using household-scale food production in the City of Tshwane*** investigates the community's perceptions and utilisation of vertical food production and vegetables, specifically traditional African vegetables. The study aims to determine the potential applications of edible living wall systems (LWSs) with traditional African vegetables (TAV) for household food production in informal settlements in Gauteng.

This questionnaire aims to understand social perceptions and factors hampering local communities using living walls for urban food production in informal communities.

Your community were chosen as a respondent because you are an informal community in the City of Tshwane.

Your participation is voluntary, and you can withdraw at any time without penalty. Your privacy will be protected throughout the survey, and your participation will remain confidential. I do not wish to analyse data individually; all data will be transferred to a computer program to analyse the entire group. This means that you are assured of anonymity.

If you agree to participate, please complete the survey that follows this cover letter. By completing the survey, you indicate that you voluntarily participate in this research. It should take about 20 minutes of your time at the most. If you have any concerns, don't hesitate to contact me with the detail provided below.

Ms Jordan Close

Email: Jordan.close@gmail.com

Phone: 078 460 5048

By selecting the "Yes" option, I hereby voluntarily grant my permission for participation in this anonymous survey. The nature and the objective of this research have been explained to me, and I understand it.

I understand my right to choose whether to participate in the research project and that the information provided will be handled confidentially. I am aware that the survey results may be used for academic publication.

☐ Yes

☐ No

Annexure C

QUESTIONNAIRE

This project aims to understand the potential application of edible living wall systems for household food production in Gauteng informal settlements. The research objective is to understand the community's perceptions and utilisation of vertical food production and traditional African vegetables.

Please indicate your preference for each question below according to the response categories. Please mark the applicable categories with an "X".

SECTION A: BIOGRAPHICAL DETAILS

This section will assist the study in better understanding the background of the respondents participating in this questionnaire.

A1. With which gender do you associate?

Male	Female	Neither
1	2	3

A2. Please select the age group applicable to you.

0 to 19 years	1
20 to 29 years	2
30 to 39 years	3
40 to 49 years	4
50 to 59 years	5
60 years or over	6

A3. Where did you grow up?

South Africa	1
SADC (Angola, Botswana, DR Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe)	2
Other, please specify…….	3

A4. How long have you been residing in South Africa?

0 to 3 years	1
3 - 5 years	2
6 - 10 years	3
more than 10 years	4

A5. What is your profession?

Unemployed	1
Energy/ oil/ gas	2
Retail	3

Education	4
Construction	5
Health	6
Food	7
Government	8
Other (please specify)	9

A6. Which category of income do you fall in?

Below minimum wage	1
Above minimum wage	2
Below R10000 per month	3
Between R10000 and R20000 per month	4
More than R20000 per month…….	5

SECTION B: Applying living wall systems with food plants

		No	Yes
B1.1	Have you grown a vegetable garden for your use?	0	1
B1.2	Do you know a friend/ family member who grows vegetables for their use?	0	1
B1.3	If yes to B1.1/ B1.2, are the vegetables grown in the person's yard?	0	1
B1.4	If yes to B1.1/ B1.2, are the vegetables grown in a communal space?	0	1
B1.5	*(After showing a picture of a living wall and explaining what it is and the benefits)* Have you seen/ used a living wall for plant production?	0	1
B1.6	Would you grow vegetables in a living wall to use in your household?	0	1

B2. If yes to B1.6, what are the benefits of vertical plant production in your opinion?

Save space when there is limited land available.	1
Will assist with the cooling of the house/ shack and environment	2
The food garden is close-by for security and maintenance reasons.	3
Will beautify the living environment	4
It will be more affordable than traditional food production if recycled materials are used.	5
Other (specify)….	6

B3. If no to B1.6, what are the disadvantages of vertical plant production in your opinion?

Costly to build and maintain	1
Don't know how to build and maintain LWS with food plants	2
Other (specify)…	3

B4. If yes to B1.1,

B4.1. Where and when did you grow a vegetable garden?

Specify where…….
Specify when…….

B4.2. What vegetables do you grow?

Specify…….
Specify…….
Specify…….
Specify…….
Specify…….

B4.3 Why do you grow vegetables?

Own consumption
Economic reasons (selling)
Personal enjoyment
Nutritional preferences
Other (Specify)…….

B5 What is the biggest challenge in growing vegetables for your household?

Indicate whether you agree/ disagree with each of the following statements by selecting; 1=Disagree, 2=Neither disagree nor agree, or 3=Agree.

		Disagree	**Neither disagree nor**	**Agree**
B5.1	Installation costs	1	2	3
B5.2	Availability of space/ land	1	2	3
B5.3	Availability of plants/ seed	1	2	3
B5.4	Availability of/ access to clean water	1	2	3
B5.5	Cost of plants/ seed	1	2	3
B5.6	Maintenance costs related to pests and diseases	1	2	3
B5.7	Maintenance costs relating to watering crops	1	2	3
B5.8	Theft and security	1	2	3
B5.9	Contamination	1	2	3
B5.10	Cost of fertilisers	1	2	3
B5.11	Protection from the sun	1	2	3
B5.12	Other (please specify)……..	1	2	3

B6. If no to B1.1,

		No	Yes
B6.1	Do you eat vegetables?	0	1
B6.2	Do you buy vegetables from a shop?	0	1

SECTION C: Traditional African Vegetables

		No	Yes
C1.1	Do you eat vegetables?	0	1

C1.2 If yes, where do you get your vegetables?

Informal shop	1
Shop	2
Other (please specify)	3

C2. Do you prefer to eat;

		No	Yes
C2.1	Traditional African vegetables such as Amaranth, Kale, pumpkin, nightshade and Gushe	0	1
C2.2	Mainstream vegetables such as lettuce, cabbage and spinach	0	1

C3. If yes to C2.1, why do you prefer traditional African vegetables?

		No	Yes
C3.1	Taste	0	1
C3.2	Availability and cost	0	1
C3.3	Easy-to-use recipes and preparation	0	1
C3.4	Medicinal/ nutritional value	0	1
C3.5	Childhood memories	0	1
C3.6	Culture/ tradition	0	1
C3.7	Other (specify)……..	0	1

C4. If no to C2.1, why don't you prefer traditional African vegetables?

		No	Yes
C4.1	Taste	0	1
C4.2	Availability and cost	0	1
C4.3	No/ limited recipes	0	1
C4.4	Viewed as old fashioned/ poverty crop	0	1
C4.5	Other (Specify)……..	0	1

C5. If yes to C2.1, what traditional African vegetables do you eat?

Specify…….
Specify…….
Specify…….
Specify…….
Specify…….

C6. Why do you eat these vegetables in C5?

		No	**Yes**
C6.1	Taste	0	1
C6.2	Availability and cost	0	1
C6.3	Easy-to-use recipes and preparation	0	1
C6.4	Medicinal/ nutritional value	0	1
C6.5	Childhood memories	0	1
C6.6	Culture/ tradition	0	1
C6.7	Other (specify)……..	0	1

Thank you for taking the time to complete this survey.

Annexure D

Informed consent form (Form for research participant's permission)

1. Project information

1.1 **Title of the research project:**

Analysing the barriers that exist in informal urban communities for applying/ using household-scale food production in the City of Tshwane

1.2 **Researcher details:**

Jordan Close & James Seeliger (Supervisor: Ms Karen Botes)

Department of Architecture (University of Pretoria)

Email: karen.botes@up.ac.za

Tel: 012 420 4128

1.3 **Research study description**

i. Project and project objectives:

This project aims to determine the potential applications of edible living wall systems (LWSs) with traditional African vegetables (TAV) for household food production in informal settlements in Gauteng. The research objectives are to understand the community's perceptions and utilisation of vertical food production and TAV. A better understanding of social perceptions and factors hampering local communities using LWSs and TAV is necessary. The capturing of these perceptions and factors will guide future designs considering edible green infrastructure such as LWSs and TAV in informal urban communities.

ii. **Participants will be required to:**

View photos of LWSs and respond about their preferences, applications, needs and perceptions of food production of leafy vegetables in living walls.

iii. **The risks to participants:**

No psychological, physical, social, economic or environmental risks are foreseen. The research entails collating and analysing community perceptions on growing vertical edible gardens and consumption of leafy vegetables and traditional African vegetables.

2. Informed consent

2.1 I, *(name of participant)*_____, hereby voluntarily grant my permission for participation in the project as explained to me by

_____

2.2 The nature, objective, possible safety and health implications have been explained to me, and I understand them.

2.3 I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the investigation results may be used for publication.

2.4 Upon signing this form, the participant will be provided with a participant slip.

Signed: _____ Date: _____

Witness: _____ Date: _____

Researcher: _____ Date: _____

Consent number

Participant Slip:

Analysing the barriers that exist in informal urban communities for applying/ using household-scale food production in the City of Tshwane

Purpose:

The purpose of this study is to document the community's perceptions and barriers to the utilisation of vertical food production with vegetables, specifically traditional African vegetables.

Information:

If you have any questions, contact Ms Karen Botes, karen.botes@up.ac.za (012 420 4128).

Consent number

Annexure E

ETHIC APPLICATION: EBIT/29/2023

Application Information			
Application Status	**Conditionally Approved**		
On who's desk	**Applicant**		
Application Date	**2023-02-28**	**Committee Cut-off Date**	**2023-03-10**

Step 1 - Applicant Information		
Empl ID	**18043811**	**Ms JA Close**
Phone	**0836612282**	
Email	**u18043811@up.ac.za**	
Position	**UP Student**	
Research for	**Masters**	
Dissertation	**Mini Dissertation**	
Faculty	**00012**	**EBIT**
Department	**00202**	**Architecture**
Application type	**EBIT**	

Step 2 – Application form

1. Project Title
South African informal communities' preceptions of living walls for household-scale food production

Short Description
A paradigm shift is necessary to reconfigure the food systems in Africa and the Global South in response to growing planetary concerns. These concerns include contributions to address poverty, food security, decent work and economic growth, sustainable cities, climate change and biodiversity. A prime contemporary research focus is the potential of living walls to improve urban small-scale, vertical outdoor food production (Nagle et al., 2017). Localised food production holds significant benefits in terms of the contribution to ecosystem services and decreased GHG emissions due to the reduced transportation of food from remote areas (Lee et al., 2015, Russo et al., 2017). Moreso, African orphan crops and TAVs have numerous advantages over exotic food crops due to their tolerance to local climate conditions, their high nutritional value, the short growing season required and the low maintenance requirements for irrigation and agrochemicals (Araya, 2014). African vegetables are more resistant to pathogens than exotic vegetables (Aworh, 2018). However, using LWS and TAVs for household-scale food production is hampered by several factors. The project investigates the perceptions of South African (SA) urban communities of living wall systems and traditional African vegetables. These perceptions will be captured through an exploratory interpretive research approach, entailing fieldwork with researcher-administered questionnaires to record household perceptions of edible LWSs and TAV. This will assist in understanding the potential opportunities and threats related to rolling out projects with LWSs and TAV in SA informal communities.

Is this study related to another study? Yes EBIT/28/2023

2. Short Literature review
With the world passing the one-third mark of its journey to meet the 2030 Agenda for Sustainable Development goals, current trajectories not in line to meet global goals by 2030 are exacerbated by the impact of the COVID-19 pandemic (United Nations Statistics Division, 2020). The global food system relies on five principal kinds of cereal as critical components of the human diet and only 30 crops to provide for the nutritional requirements of the human population (Mabhaudhi et al. 2018). The human population will be more vulnerable if one of these crop species falters due to climate change. This makes food systems vulnerable to climate variability, especially in marginalised countries such as South Africa. A paradigm shift to reconfigure the food systems in Africa and the Global South in response to growing planetary concerns is necessary.African orphan crops (AOC) include edible, under-researched crops adapted to Africa's extreme climate and soil stresses (AOCC, 2020). These crops are still used in traditional local diets and are locally indigenous to Africa or have been introduced to Africa centuries ago (AOCC 2020). Vegetables, cereals, legumes, fruit and root crops form the AOC categories (National Research Council (NRC), 2006, Tadele and Assefa, 2012)). Towns and Shackleton (2019) proposed the term traditional African vegetables (TAV) to describe nutrient-dense species. TAVs have the potential for sustainable and resilient small-scale agriculture and food systems in the Global South as they are adapted to local conditions (Mabhaudhi et al., 2017, Maseko et al., 2017). Food security is crucial to address food-insecure households in South Africa (Altman et al., 2009). Food production of TAV shows potential (Mabhaudhi et al. 2017; Mabhaudhi et al. 2019) but needs to be drastically increased to provide for the growing population in Africa (Tadele and Assefa, 2012). TAV are a resilient option to address food security considering the local conditions of the global south, involving mainly semi-arid to arid conditions with intense weather extremes due to climate change. However, awareness of the nutritional value of TAV needs to be increased amongst SA urban communities. Taste is argued to be an essential criterion for selecting TAVs for cultivation, followed by marketability, biomass yield, and ease of collection and processing, based on a study in Ethiopia (Kidane et al. 2015). Exotic crops replaced

AOC and TAV in colonial SA, which resulted in their relegation and neglect (Mabhaudhi et al., 2018). Exotic vegetables are preferred over local vegetables in SA urban areas.This is due to several reasons, including the local community's perceptions. In cities with limited ground space, the potential area for facade greenery is almost double the footprint of buildings, with the potential to offer more environmental benefits than green roofs (K öhler, 2008). However, research on living wall systems (LWSs) reports that, despite the psychological and aesthetic benefits, the economic feasibility of LWSs needs improvement ((Mårtensson et al., 2016, Russo et al., 2017, Ling and Chiang, 2018). A way to increase the economic feasibility of LWSs is to introduce edible crops (Mårtensson et al. 2016; Russo et al. 2017; Ling and Chiang 2018). Urban small-scale food production involving LWS and TAV shows the potential to contribute to household food security and associated SDGs in SA. Although people's perceptions of TAV have been assessed in research studies, research on using LWSs with TAV for household-scale food production in SA informal communities is required. Vegetable consumption is further associated with demographic factors such as age, gender, employment, education level and availability (Xaba, T. and Dlamini, S., 2021) . Moreso, income has been found to impact consumption, with lower incomes associated with low-nutrition foods (Chen, S. E., Liu, J. and Binkley, J. K., 2012).

3. Aims and Objectives of the Project

The research objectives are to understand the community'sperceptions and utilisation of vertical food production and TAV.A better understanding of social perceptions and factors hampering local communities using LWSs and TAV is necessary. The capturing of these perceptions and factors will guide future designs considering edible green infrastructure such as LWSs and TAV in informal urban communities.

4. Materials and methods

Literature review, exploratory interpretive research approach. Fieldwork will entail researcher-administered questionnaires, with randomly selected households in Plastic View as the sample group. Participants will be asked to view photos of LWSs and questioned on their preferences, applications, needs and perceptions of food production of leafy vegetables.

5. Conduct with regard to data when information becomes irrelevant / when the project is stopped

6. Duration of the Project

Proposed commencement date: 2023-03-31
Proposed finalisation date: 2023-07-24

7. Research environment – Where will the study be conducted?

Community	

8. Research Team

Principal Investigator	Ms JA Close		u18043811@up.ac.za	0836612282
Student's Supervisor	Mrs KL Botes		karen.botes@up.ac.za	0828934702

9. Agreement between researchers

Name	Right to use the results in a dissertation or thesis	Right to present the results at a Conference	Right to publish the results in a Science Journal	Right to publish the results through a Non-Science medium	Right to Co-Authorship	N/A
Ms JA Close	Yes	Yes	Yes	Yes	Yes	
Mrs KL Botes	Yes	Yes	Yes	Yes	Yes	

10. Project Funded? No

11. Will people be recruited as research participants? Yes
How many groups of participants will be included? 1

Group name: Residents of Plastic View informal settlements
Sample size: 60

Classified Participants

Adults over 18 years

Additional consent required

Method to obtain information
Questionnaire

Inclusion/Exclusion criteria
Minimum 18 years old, and must be literate in English

Estimated literacy level
3) Medium

Expect all participants to be able to read? Yes

Expect all participants to understand English? Yes

How will the participants be recruited?
The participants will be recruited through simple random sampling via the community leadership.

What will the participants be asked to do?
Participants will be asked to answer questions related to their demographic and biographical details, and perceptions on using living wall systems with food plants, and growing and consuming vegetables and tradional African vegetables.

What will their data / samples be used for?
Data will be used to inform design and research on implementing edible living walls with traditional African vegetables in South African urban communities. Data will be used in master and honours student's mini-disserations and possible journal articles co-authored by the researcher and the MProf students.

Who will carry out these procedures?
Myself and colleague and study leader

Describe the manner in which confidential information will be handled, and in which confidentiality will be assured
All participants will remain anonymous and confidentiality will be assured by explaining the consent and providing them with a tear-off slip as proof following their written consent.

Describe what you will do to obtain informed consent/assent from your participants (or their caregivers in the case of underage participants)
All participants will be provided with a consent approval letter, which will also be explained to them. Written consent will be obtained.

Detail the measures you will take to ensure that participation is voluntary
Participants will be informed verbally and in writing that participation is voluntary.

Will participants be rewarded / reimbursed for participation? No

12. Involvement of people as participants (Health only)

Participants	Methods
Children younger than 18	Focus Group
A Clinical Case study	Interview
People with HIV and AIDS	Questionnaire
Genetic / Genomic Research	Other methods
Medication Trial	
UP Staff or Students	

Other method:

13. Laboratory Procedures
Will any experiments be done in a laboratory? No

14. Principal Investigator(s) Declaration for the storage of research data and/or documents

I, the Principal Investigator(s),	Ms JA Close
of the following trial/study titled	South African informal communities' preceptions of living walls for household-scale food production

will be storing all the research data and/or documents referring to the above mentioned trial/study at the following address:

Address Line 1	UP Campus,

Address Line 1	Ring Rd
Address Line 1	Elandspoort 357-Jr,
Address Line 1	
City	Pretoria
Postal Code	0001

(This period includes the time needed for performing the research as well as writing up the results)

Start Date of Trial/Study	2023-03-31
End Date of Trail / Study	2023-07-24

I understand that the storage of the abovementioned data and/or documents must be maintained for a minimum of 10 years from the commencement of this trail/study.

Until which year will data be stored:	2033
Start of Storage Date	2023-03-31
End of Storage Date	2033-03-31

I hereby understand and agree to this declaration: Yes

15. Declaration of Helsinki:

16. Data / samples recorded/collected at the point of measurement

Paper questionnaire / survey

Data / samples stored and archived

UP Repository

17. Will secondary data be used in this research? No
Is the data publicly available and obtainable (i.e. without compensation) and/or paid for by UP?

18. Intellectual property (IP)

Will all intellectual property be owned by UP?	Yes
Conflict of interest with respect to IP?	No

19. Categorise the risks associated with the project? 1) No more than minimal risk

20. Describe the risks associated with the research and how you tried to reduce these risks
No psychological, physical, social, economic or environmental risks are foreseen, as the research entails collating and analysing community perceptions on the growing of vertical edible gardens and consumption of leafy vegetables and tradtional African vegetables.

21. Benefits associated with the research
Describe any benefits to participants
No current benefits exist for participants. However, the research will contribute in establishing sustainable communities, and enhancing food security (SDG2) for future communities.

Describe benefits associated with the research
The capturing of perceptions and factors relating to community perceptions on using living wall systems (LWSs) to produce leafy vegetables and traditional African vegetables (TAV) will guide future designs considering edible green infrastructure such as LWSs with TAV in informal urban communities.

22. Planned application of results

Publ: Thesis / Dissertation

23. Additional approval or formal permissions? No

24. Confidentiality clause and Pty Ltd issues? No

25. Does the study require the use of hazardous materials?	No
Does the doing of the research have an environmental impact?	No

26. Will animals (dead or alive) or animal derived products (any retrospective samples including bacterial, viral, protozoal and DNA isolates) be used for research or testing purposes? No

27. Will genetically modified organisms be used in the research? No

28. References

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29. Declaration

I accept and will adhere to all stipulations pertaining to ethically sound research as locally, nationally and internationally established.	Yes
I will conduct the study as specified in the application and will be principally responsible for all matters related to the research.	Yes
I shall communicate all changes to the application or any other document before any such is executed in my research, to obtain the necessary permissions from the Ethics Committee.	Yes
I will not exceed the terms or reference of the research application or any other documents submitted to the Ethics Committee.	Yes
I confirm that I'm not seeking ethics clearance for research that has already been carried out.	Yes
I affirm that all relevant information has been provided and that all statements made are correct.	Yes
I have familiarised myself with the University of Pretoria's policy regarding plagiarism http://www.aibrary.up.ac.za/plagiarism/index.htm . Plagiarism is regarded as a serious violation and may lead to suspension from the University.	Yes
Research participants will be informed, information will be handled confidentially, research participants reserve the right to choose whether to participate and, where applicable, written permission will be obtained for the execution of the project.	Yes
No conflict of interests or financial benefit, whether for the researcher, company or organisation, that could materially affect the outcome of the investigation or jeopardise the name of the university is foreseen.	Yes
Inspection of the experiments in loco may take place at any time by the committee or its proxy.	Yes
The information I furnish in the application is correct to the best of my knowledge and that I will abide by the stipulations of the committee as contained in the regulations.	Yes

30. Acknowledge that I read and understood the information related to the POPI Act? Y

31. Is this study Health Related? No

Will Medication Trials be used?